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DECEMBER 1959
VOL. 2 • NO. 12

- Nalos — Present State of Art in High-Power Traveling-Wave Tubes
- Albanese — A Broadband Antenna Shield and Test Coupler
- Ishii — Impedance Adjustment Effects on Reflex Klystron Amplifier Noise

the microwave journal

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Kellogg Switchboard & Supply
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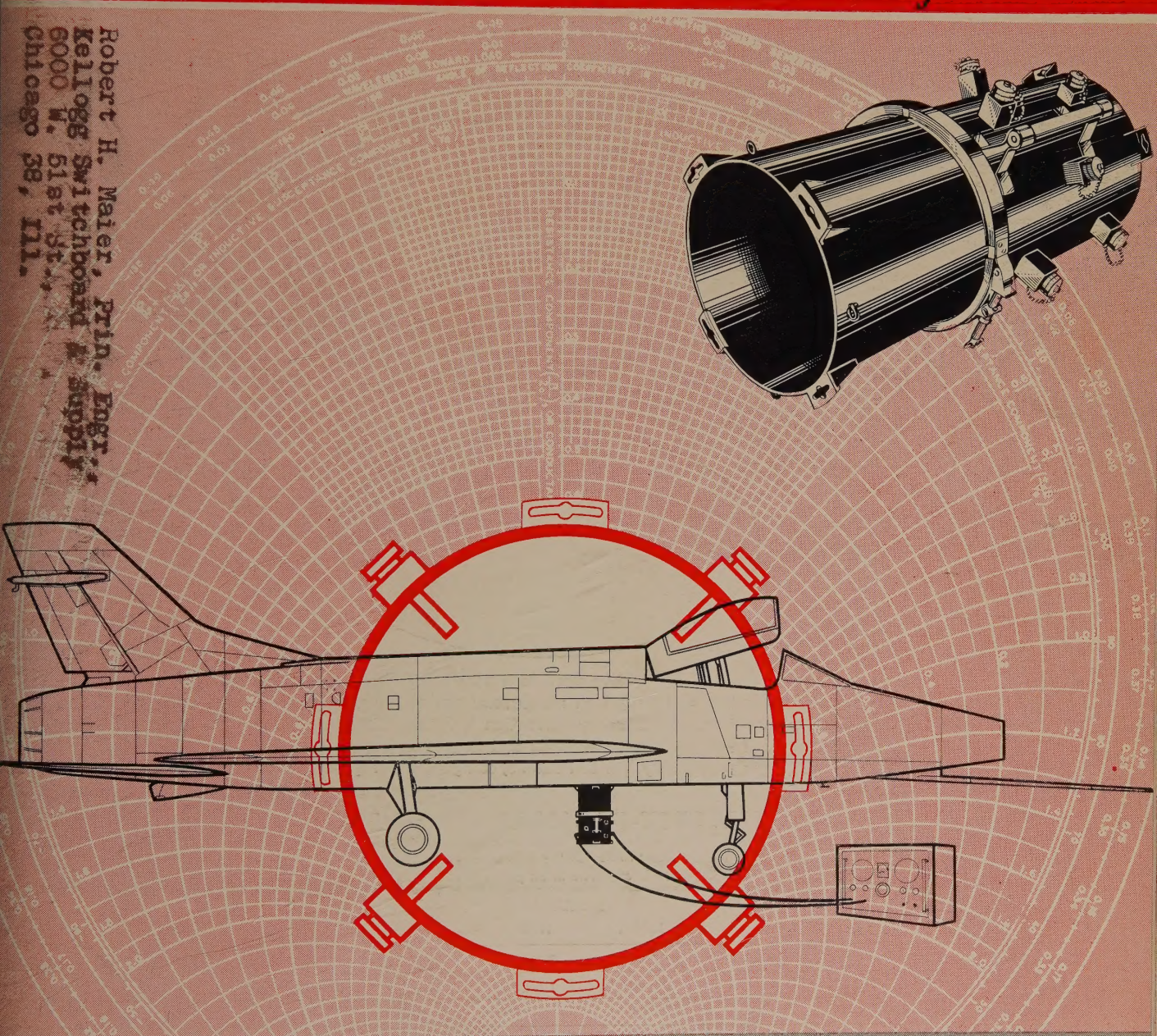
Chicago 38, Ill.



In This Issue . . .

CUMULATIVE INDEX TO VOLUMES I and II

For utmost accuracy, these new Precision Attenuators depend on mathematical law instead of resistivity

New "barrel" design (shown) on K and R band models; time-tested original design (same principle) on G through P band models. Phase shift constant with attenuation. Attenuates 0 to 50 db; SWR less than 1.5 full range. High stability; unaffected by frequency, temperature or humidity changes. Direct reading; no charts or interpolation. Up to 15 watts capacity; simple, one-control tuning; large dial.

The new -hp- 382A series attenuators provide a completely reliable, true standard of attenuation for calibration or comparison measurements. Unlike waveguide-below-cutoff or resistive-film attenuators, no frequency correction is required. Attenuation is a function of mathematical laws of rotating electrical fields and is precisely accurate under all ambient conditions. Extremely compact, sturdy. For full details, call your -hp- representative or write direct.

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CABLE "HEWPACK" • DAVENPORT 5-4451
Field engineers in all principal areas

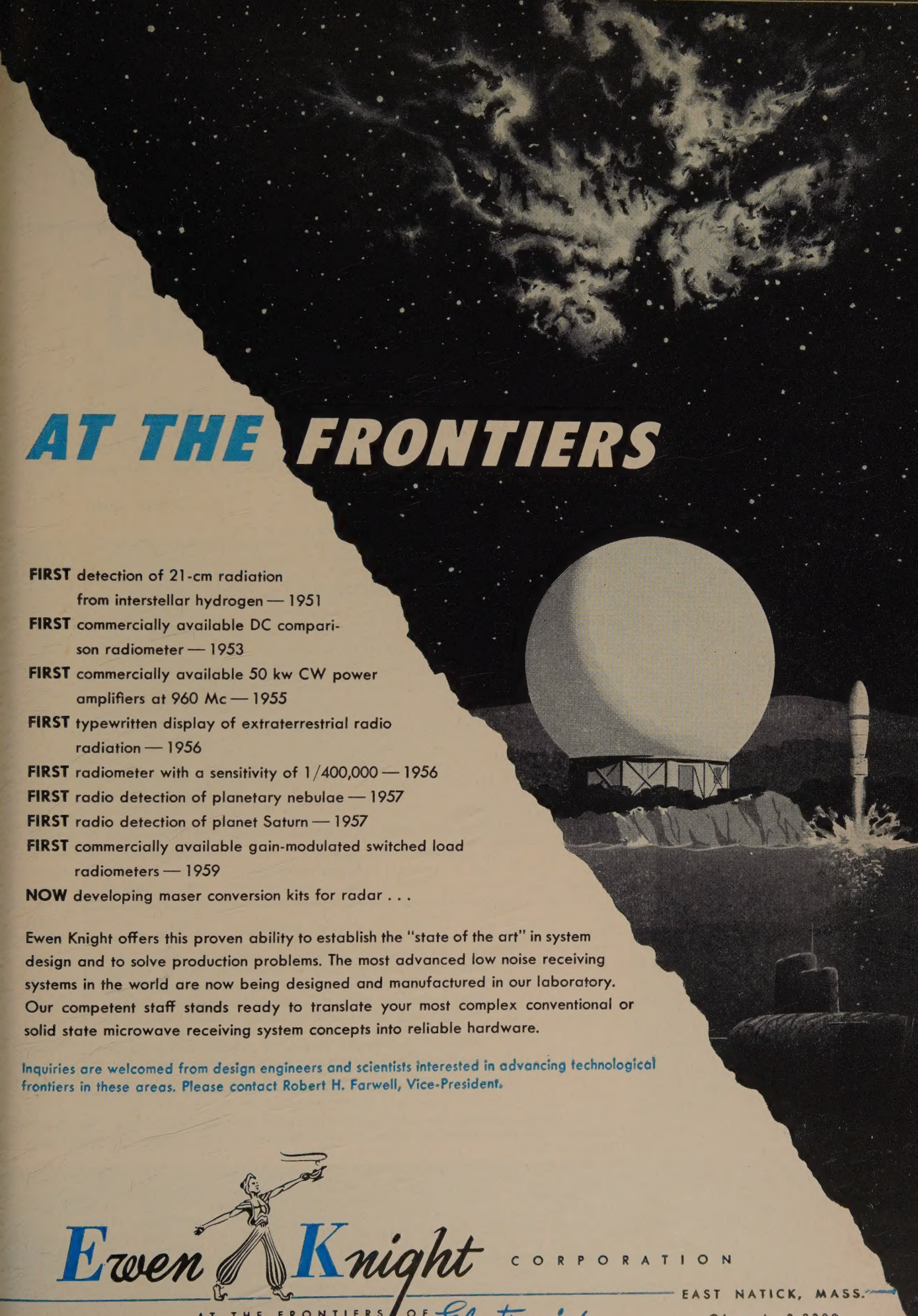
SPECIFICATIONS

	G382A	J382A	H382A	X382A	P382A	K382A	R382A
Frequency Range, KMC:	3.95 - 5.85	5.3 - 8.2	7.0 - 10.0	8.2 - 12.4	12.4 - 18.0	18.0 - 26.5	26.5 - 40.0
Waveguide Size:	2 x 1"	1½ x ¾"	1¼ x ⅝"	1 x 1.2"	0.702 x 0.391"	½ x ¼"	0.36 x 0.22
Power-handling capacity, watts:*	15	10	10	10	5	3	2
Price:	$500.00	$350.00	$350.00	$275.00	$275.00	$425.00	$450.00

*Average, continuous duty.

Data subject to change without notice. Prices f.o.b. factory.

standard of measuring speed and accuracy



AT THE FRONTIERS

FIRST detection of 21-cm radiation from interstellar hydrogen — 1951
FIRST commercially available DC comparison radiometer — 1953
FIRST commercially available 50 kw CW power amplifiers at 960 Mc — 1955
FIRST typewritten display of extraterrestrial radio radiation — 1956
FIRST radiometer with a sensitivity of 1/400,000 — 1956
FIRST radio detection of planetary nebulae — 1957
FIRST radio detection of planet Saturn — 1957
FIRST commercially available gain-modulated switched load radiometers — 1959
NOW developing maser conversion kits for radar . . .

Ewen Knight offers this proven ability to establish the "state of the art" in system design and to solve production problems. The most advanced low noise receiving systems in the world are now being designed and manufactured in our laboratory. Our competent staff stands ready to translate your most complex conventional or solid state microwave receiving system concepts into reliable hardware.

Inquiries are welcomed from design engineers and scientists interested in advancing technological frontiers in these areas. Please contact Robert H. Farwell, Vice-President.

Ewen Knight CORPORATION

AT THE FRONTIERS OF Electronics

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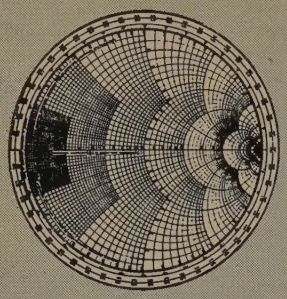

the microwave journal

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Next Issue

Millimeters - The New Radio Frontier — Present State of Art in High Power TWT's - Part II — Measurement of Varactor Quality

COVER PICTURE

This month's cover symbolically depicts the Bogart Antenna Coupler being used to Flight-line test an aircraft antenna. The coupler permits normal operation of the radar transmitter without danger of interference to nearby receivers, and allows antenna testing without removal of the piece under test, from the aircraft. See page 39.

Cover design by Mr. Ronald M. Scholer, of the Bogart Manufacturing Corporation, Brooklyn, New York.

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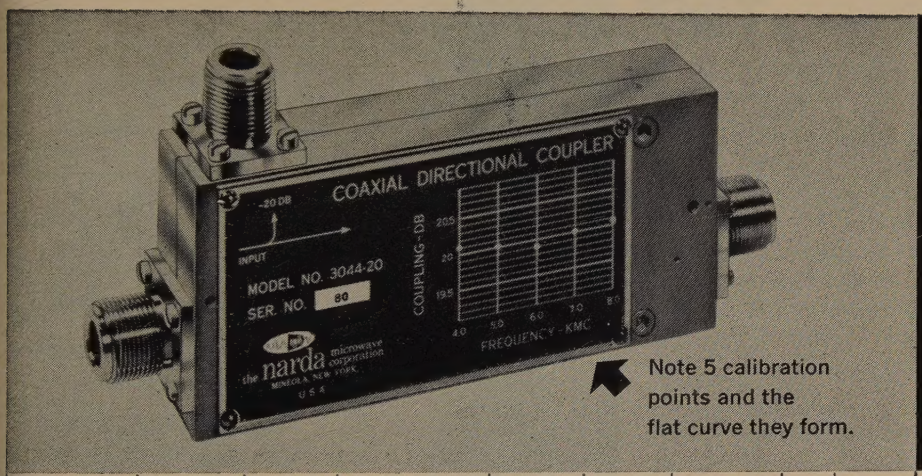
NEW FROM NARDA

THE INDUSTRY'S FLATTEST COAX COUPLER!

Only 0.2 db variation over full octave!

What more is there to say? The new series of Narda Coaxial Couplers is absolutely the flattest on the market; the specs are here; the prices are here. And you know Narda's reputation for quality! If you need a really flat coupler, contact your Narda representative, or write to us directly.



Note 5 calibration points and the flat curve they form.

Coupling Characteristics

Frequency Response ±0.2 db

Deviation of Mean Value from Nominal ±0.3 db

Calibration Accuracy ±0.1 db

Calibration points at 5 frequencies

Connectors: Series N female; others on special order.

Frequency ↄ (mc)	Nominal Coupling	NARDA Model	VSWR Primary, VSWR Secondary	Minimum Directivity (db)	FORWARD (watts)	Power Rating REV. (watts)	PK. (kw)	Price
240-500	20	3040-20	1.1/1.2	20	1000	100	10	
500-1000	20	3041-20	1.1/1.2	20	1000	100	10	
950-2000	20	3042-20	1.1/1.2	20	1000	100	10	
2000-4000	20	3042-20	1.15/1.2	20	1000	200	10	$200
4000-8000	20	3044-20	1.2/1.25	17	1000	200	10	
7000-11,000	20	3045-20	1.25/1.3	15	1000	200	10	

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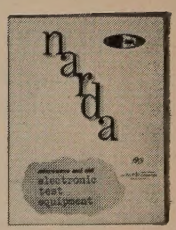
Write for your free copy of Narda's new 1959 catalog. Address: Dept. MJ-14.



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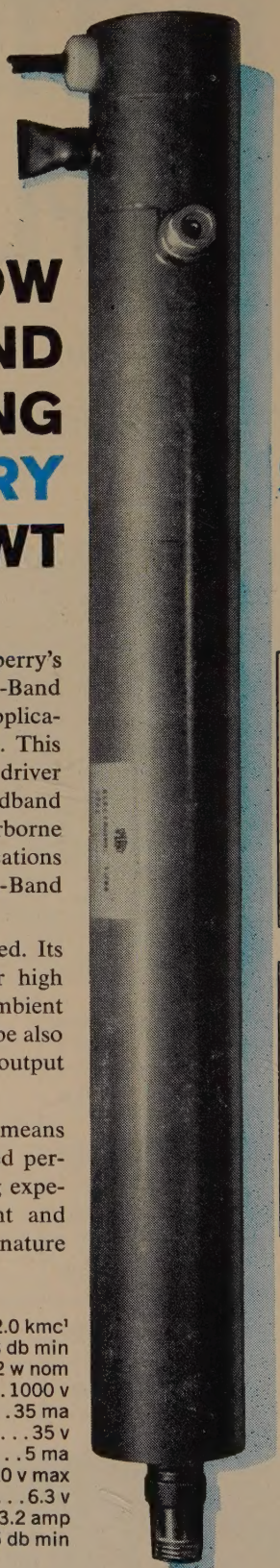
Precision is assured at **SPERRY**

Quality is closely guarded in TWT production. Here optical comparator magnifies helix for inspection.



NOW 60DB GAIN IN L-BAND PPM FOCUSING NEW SPERRY TWT

STL-222

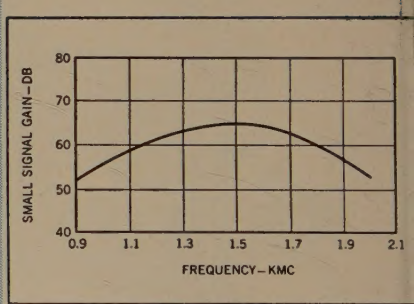
. . . cuts Space, Weight, Cost, Power Requirements — Sperry's new STL-222 provides twice the gain of ordinary L-Band tubes—actually takes the place of two tubes in most applications — yet is only 20″ long, weighs only 8.5 pounds. This important advantage suits this new CW amplifier and driver perfectly to airborne applications. Its excellent broadband stability recommends it for ground support and airborne radar equipment . . . communications . . . drone applications . . . noise generators . . . switching devices and other L-Band uses.

The STL-222 is periodic permanent magnet focused. Its tough metal and ceramic construction provides for high environmental capability, stable operation at high ambient temperatures and under extremes of vibration. This tube also features a high-mu modulating grid and high input-to-output isolation. It is short circuit stable.

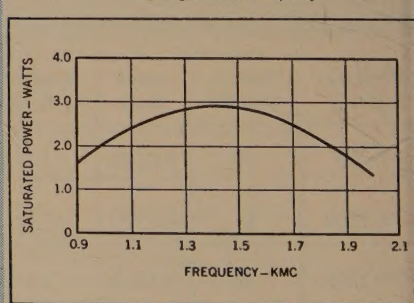
The STL-222 is now in production at Sperry, which means lower unit cost and fast delivery schedules. Advanced performance and dependability result from Sperry's long experience in klystron and TWT research, development and production. Write for complete data, outlining the nature of your application.

Specifications

Frequency Range	1.0 to 2.0 kmc[1]
Small-signal gain	48 db min
Saturated Power Output	2 w nom
Beam Voltage	1000 v
Beam Current	35 ma
Grid Bias	35 v
Grid Current	5 ma
Grid Cut-off Signal	−20 v max
Heater Voltage	6.3 v
Heater Current	3.2 amp
Input-Output Isolation	75 db min



Small-Signal Gain vs. Frequency



Saturated Power vs. Frequency

SPERRY

SPERRY ELECTRONIC TUBE DIVISION, *SPERRY RAND CORPORATION, GAINESVILLE, FLORI*

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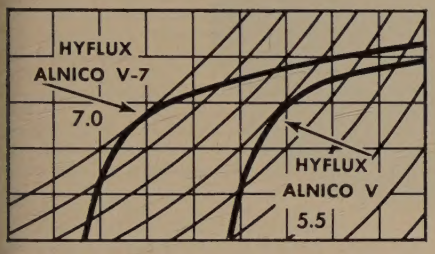
NEW HIGH ENERGY ALNICO V-7 PERMANENT MAGNETS ACHIEVE TYPICAL ENERGY VALUES OF 7 MILLION FOR THE FIRST TIME!

For the design engineer with a special application problem

Hyflux Alnico V-7 is a new high energy material now available for special applications requiring either *greater energy* per unit weight or volume, or *equal energy* from a lighter or smaller magnet.

Compared with the previous energy leader — Alnico V, new Hyflux Alnico V-7 represents a significant advance in the energy level of permanent magnets. To show this, a portion of the Demagnetization and Energy Product Curve has been enlarged and depicted here.

The curve for Hyflux Alnico V-7 shows a typical energy value of 7.00



million. By comparison, Alnico V has a typical value of only 5.50 million.

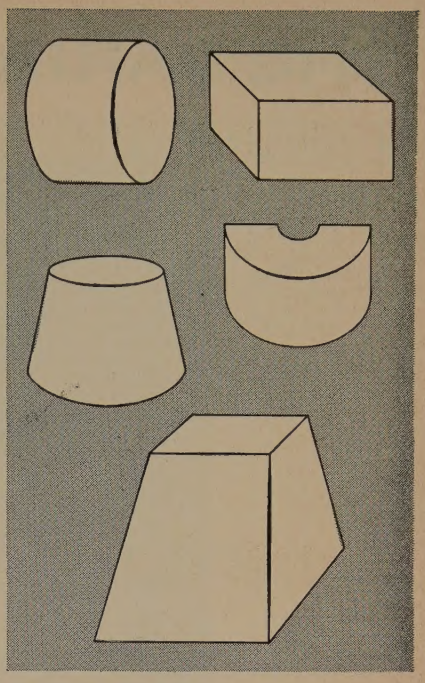
The reason for this remarkable performance lies in the very high degree of crystal magnet orientation found in the material. As a result, Hyflux Alnico V-7 produces *more magnetic energy per unit volume or weight* than any other permanent magnet material presently available.

Other characteristics of Hyflux Alnico V-7 are equally impressive. For example, residual induction (B_r) is 12,750 gausses, and the coercive force (H_c) is 765 oersteds. For Alnico V the B_r is only 12,500 gausses and the H_c 600 oersteds. Improvements such as these point the way to important design breakthroughs in many fields.

When To Use Hyflux Alnico V-7

A premium material, Hyflux Alnico V-7 is particularly suited for use in space age or other critical equipment requiring a greater level of energy, or where smaller size and weight without loss of energy is needed.

1. **Military Electronics.** Use Hyflux Alnico V-7 for light-weight ground and airborne generators and alternators (in a full range of frequencies).
2. **Testing Equipment.** Use Hyflux Alnico V-7 in meters, recording instruments, oscillographs, magnetometers and galvanometers.
3. **Miniature and Sub-miniature Components.** Use Hyflux Alnico V-7 for missile-borne guidance and recording equipment.



Designing With Hyflux Alnico V-7

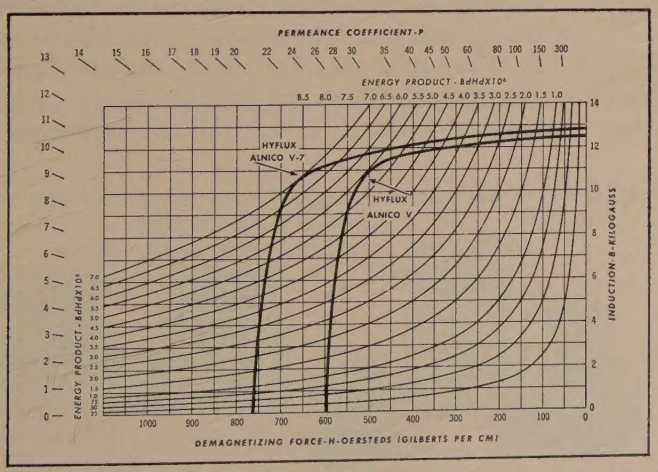
The nature of the material is such that orientation (and magnetization) must be straight, eliminating the familiar horseshoe shape. Cylinders, rectangles and other prismatic shapes, however, are possible, as are certain conic or pyramidal frustums. Pole faces may be ground quite easily. Side surfaces may also be ground, but somewhat slower than normal.

TYPICAL CHARACTERISTICS OF HYFLUX ALNICO V-7

(in comparison with Alnico V)

PROPERTIES	Hyflux Alnico V-7	Alnico V
Residual Induction (minimum) B_r Gausses	12,750	12,500
Coercive Force (minimum) H_c Oersteds	765	600
Peak Energy Product $B_dH_d$max x 10^6	7.00	5.50
Peak Magnetizing Force Oersteds	3,000	3,000
Weight (lb per cu in)	0.265	0.265
Mechanical Properties	Hard-Brittle	Hard-Brittle

For more information on new Hyflux Alnico V-7 and its role in the design future of your firm, write Dept. Q12.



DEMAGNETIZATION AND ENERGY PRODUCT CURVE

THE INDIANA STEEL PRODUCTS COMPANY

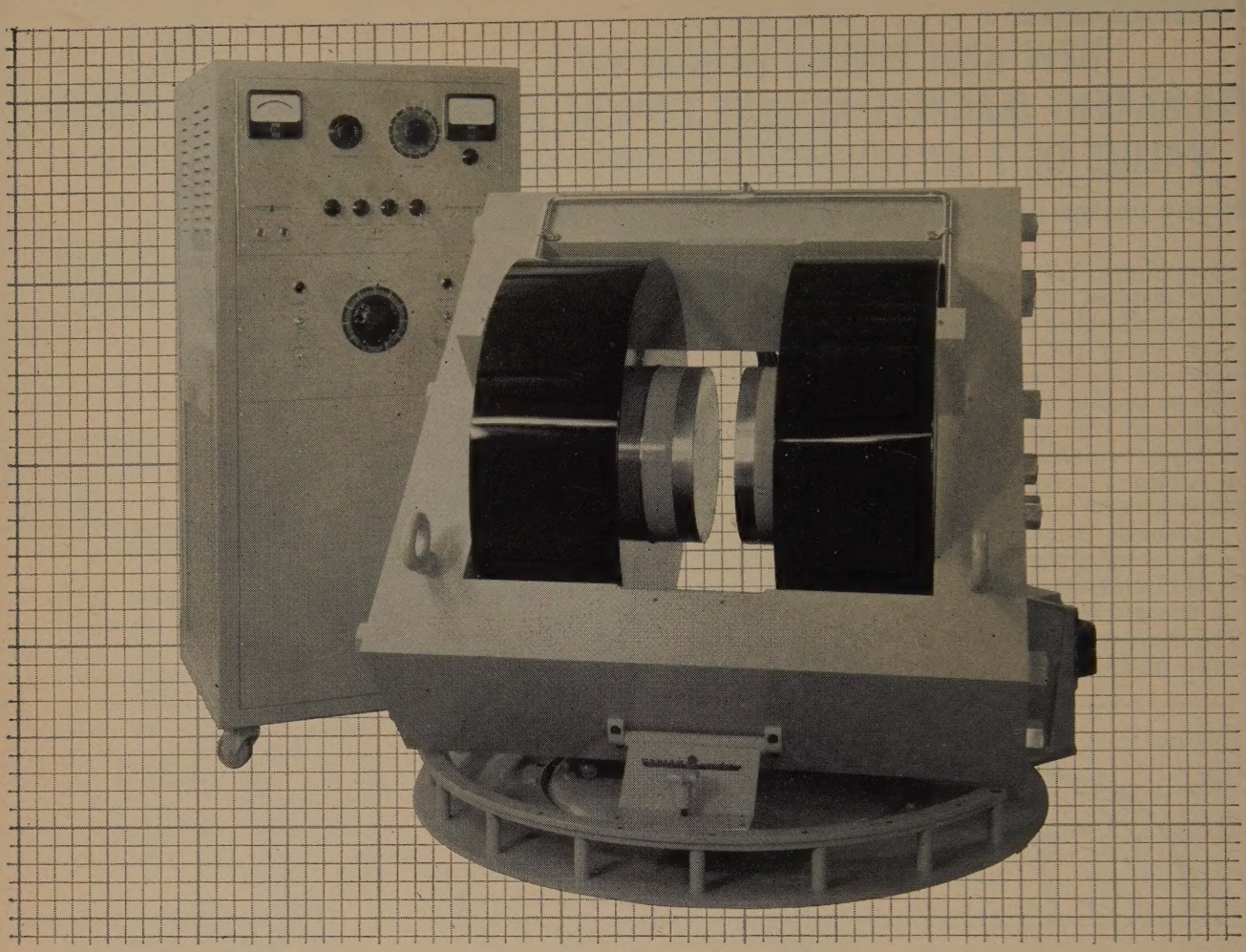
Valparaiso, Indiana

WORLD'S LARGEST MANUFACTURER OF PERMANENT MAGNETS

In Canada: The Indiana Steel Products Company of Canada Limited, Kitchener, Ont.

INDIANA PERMANENT MAGNETS

THE VARIAN MAGNET STANDARD:

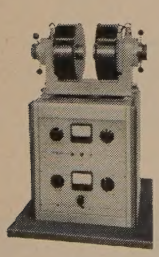


Laboratory magnet systems demonstrating outstanding field uniformity and time stability do not just "happen." Proven **performance** at the installation site is the last link in a long chain of events. The other end of the chain must be firmly secured to specialized **understanding** gained from years of painstaking research and practical experience.

For the laboratory that is progressing toward more advanced projects, Varian Magnets are the world's most precise. Such truly precise laboratory magnet systems must display time stability of magnetic field which is at least comparable to its available air gap homogeneity. Knowledgeable circuit design, use of high quality components, and excellent workmanship combine with Varian's decade of experience to achieve this necessary condition. Varian's line of power supplies ideally matches each member of the magnet family.

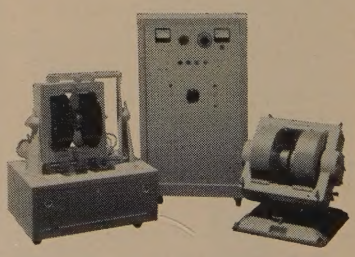
Varian magnet systems have rarely outlived their usefulness in any of the hundreds of

VARIAN'S STANDARD LINE OF LABORATORY MAGNETS—*Available on short delivery*



4-INCH GENERAL PURPOSE—V-4004

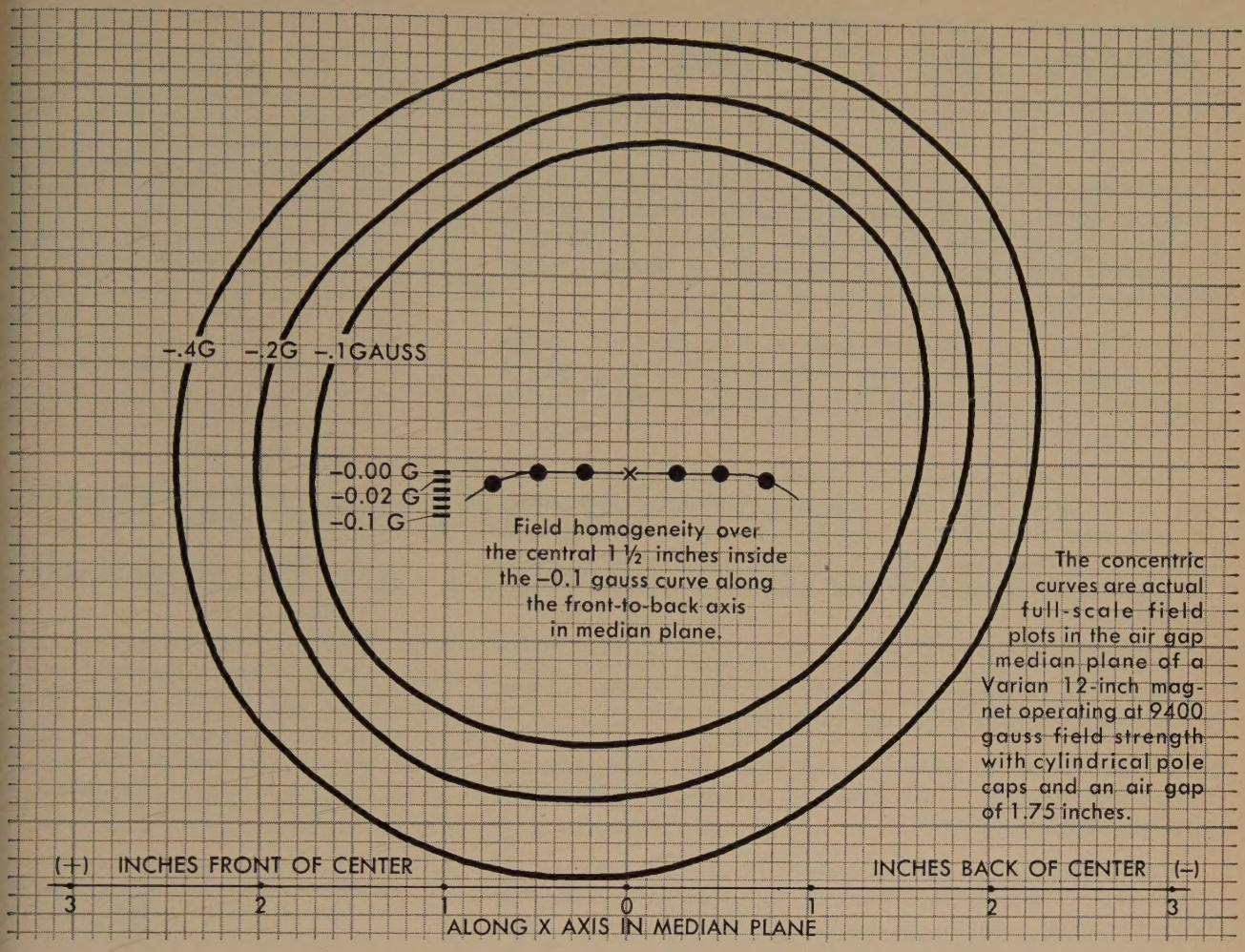
A classroom and general-purpose laboratory magnet that is very flexible, low in cost and easily moved wherever needed. Air gap is continuously adjustable by a simple turning of hand knobs. Open yoke provides easy access to gap from all sides. Photo shows magnet, power supply, and current regulator (each available individually) mounted as a single mobile unit. *One week delivery.*



6-INCH MODELS—V-4007-1 AND V-4007

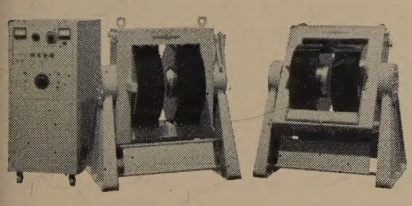
These are high-precision magnets that provide optimum field homogeneity within the inherent possibilities of the 6-inch diameter. They provide ample performance for EPR Spectrometers and many other laboratory uses. The two models each have a different rotational axis: the V-4007-1 vertical, the V-4007 horizontal. The V-4007 magnet can be supplied with shaped axial holes.

Unmatched performance through unique understanding


-.4G -.2G -.1GAUSS
-0.00 G
-0.02 G
-0.1 G
Field homogeneity over the central 1 ½ inches inside the -0.1 gauss curve along the front-to-back axis in median plane.
The concentric curves are actual full-scale field plots in the air gap median plane of a Varian 12-inch magnet operating at 9400 gauss field strength with cylindrical pole caps and an air gap of 1.75 inches.
(+) INCHES FRONT OF CENTER
INCHES BACK OF CENTER (-)
3 2 1 0 1 2 3
ALONG X AXIS IN MEDIAN PLANE

free-world laboratories where they are installed. And Varian Service Engineering encircles the globe to insure continued optimum use and performance from this equipment.

One of Varian's major scientific accomplishments is the NMR Spectrometer which attains resolution of one part in two-hundred million. Associated magnet field homogeneity and time stability are central factors in achieving such unparalleled resolution. Another significant example of Varian's magnet technology is the "shaped hole" technique (just announced) for magnet pole faces. This permits axial passage of light rays and charged-particle beams into the air gap without deteriorating the field uniformity in the sample region. These are end results of Varian's continuing magnet research and development program devoted to product improvement, design of new models and creation of accessory items.



12-INCH MODELS — V-4012-A, V-4012-3B AND V-4012A-SM
Best available field homogeneity and largest air gap working volume. The V-4012-3B rotates about vertical axis. V-4012 A offers horizontal axis yoke adjustment. V-4012A-SM is specifically for use with the Varian 60 mc NMR Spectrometer. It provides extraordinary field homogeneity over a small volume at strengths up to 14,100 gauss in a fixed air gap width of 1.75 inches.

Full performance details and equipment specifications are available in our literature. Write today to the ***Instrument Division***

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NMR & EPR SPECTROMETERS, MAGNETS, GRAPHIC RECORDERS, MAGNETOMETERS, MICROWAVE TUBES, MICROWAVE SYSTEM COMPONENTS, HIGH VACUUM EQUIPMENT, LINEAR ACCELERATORS, RESEARCH AND DEVELOPMENT SERVICES.

CIRCLE READER SERVICE CARD 5

From the Editor . . .

Each month when I go through the agonizing process of preparing an editorial, I find myself searching for a topic of interest; and then, having determined the topic, I labor over something profound to say. Since I am not by nature an editorial writer, the problem becomes extremely difficult at times.

This month I am taking the path of least resistance. In the spirit of the season I would like to thank the various people responsible for the continued growth and success of "the microwave journal."

Thanks are due our editorial board for their active participation in the areas of writing, soliciting, and reviewing papers. In some cases their reviews have been in the form of tutorial papers for the exclusive benefit of the authors. On other occasions their rejection of a paper has been firm and final with no right of appeal.

Thanks are due all of the authors of the many excellent papers we have been privileged to publish and those capable authors whose papers we have reluctantly been obliged to reject.

Thanks are due our advertisers and readers for their continued interest and support. Their letters of praise and criticism are most welcome.

Thanks are due the staff at Horizon House who have the responsibility of putting the "journal" together and printing it. With thanks are extended apologies. In 1960 I shall try to prepare my editorials sufficiently in advance so that it will not be the last item to be set in type each month.

In extending thanks at this time we should not forget some of the other groups. For example, there is the group of individuals throughout the nation who have been seen on occasions carrying the "journal" — cover side out. Keep up the good campaign. There is another group who continue to inflate our already over-inflated ego with demands for back issues to complete their files. One group we are especially proud of is located in one of our finest laboratories. We have been advised that they have converted to "the microwave journal" as must reading in their most private of all reading rooms.

The list does not end there, but I should.

Before closing, however, I would like to thank our publisher, Bill Bazzy, for his tireless leadership. To those of us associated with the "journal," 1959 will always be known as the year Bill went into orbit. Our only hope is that he will continue to make his monthly re-entry in order to sign the checks.

Ted Saad

CALL FOR PAPERS

The 4th National Convention on M itary Electronics — 1960 (MIL-E-CO will be held at the Sheraton-Park Hot Washington, D.C., on June 27, 28, 1960, under the sponsorship of the P fessional Group on Military Electron of The Institute of Radio Engineers. R ert H. Cranshaw, Manager, Advanc Space Projects, General Electric Co pany, Utica, New York, is Conventi President for MIL-E-CON. Incidental the Army Signal Corps will celebrate One Hundredth Anniversary in 1960.

Papers presenting original work military electronics are invited for th meeting. Suggested topics include, b are not limited to the following:

Current Problems of Space Technolo
Space Electronics
Ranging and Tracking
Electronic Propulsion
Data Handling Systems
Guidance and Control
Inertial Systems
Reconnaissance Systems
Communication Systems
Operation Analysis
Reliability

The technical program will incluc both classified (limited to Confidentia and unclassified sessions, with the A Research and Development Comma sponsoring the classified sessions. A unclassified and bound **Proceedings** the convention will be available at th meeting.

Prospective authors are requested t furnish the following information, n later than February 1, 1960:

Three copies of a 250-word unclass fied abstract of the proposed paper, pl the name and position of the author an the name and address of his company organization.

Each author must obtain the appr priate military and company clearanc for his abstract. Send abstracts to:

Dr. Craig M. Crenshaw, Departme of Army, Office of the Chief Sign Officer, R & D Division, SIGRD- Washington 25, D.C.

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Announcing a new family of low-noise microwave diodes. Here is a major step forward in the development and control of germanium and silicon crystal diode performance. Philco microwave diodes are designed to meet the most stringent military environmental and electrical requirements for shock, vibration, torque and strain. Each of these new diodes is unsurpassed for performance. When only the best will do . . . the experts choose Philco.

- **Exceptionally Low Noise Figure**
- **Outstanding Performance at 150° C**
- **High Resistance to Burn-Out**
- **Absolute Hermetic Seal**

1N1838

The first and only Germanium Mixer Diode specifically designed for ultra-low noise performance in Doppler receivers. Through Philco's exclusive anchor whisker construction the practical elimination of microphonics is assured. The 1N1838 is hermetically sealed and has been uniquely engineered for Doppler equipments operating at 8,800 and 13,500mc. Particular emphasis has been placed upon minimizing crystal noise in the range from 1 to 100 kc.

1N263

Here's a Hermetically Sealed Germanium Crystal Diode designed for exceptionally low noise mixer performance at X-band. It has been engineered to such a degree that its tightly controlled characteristics assure that *any* two 1N263's will be a matched pair; its symmetrical construction allows easy polarity reversal in balanced mixers. The crystal may be used fixed-tuned over the range 8600 to 9600mc. IF impedance (Z_{if}) . . . 140 to 210 ohms; RF impedance (VSWR) . . . 1.3 max; Overall noise figure (NF_{rec}) . . . 7.5db max.

1N26
1N26A
1N26B

These Silicon Mixer Diodes bring tremendously improved performance to this family designed for high reliability operation in the 24,000mc region. As a result of Philco's unparalleled engineering activity in this area, existing performance limits in the 1N26 series have been greatly extended: by addition of the 1N26B . . . maximum operating temperature more than doubled (to 150° C.); VSWR reduced to 1.5; IF impedance range narrowed (400 to 600 ohms). All members of this family have a metal-to-ceramic hermetic seal guaranteeing reliable performance under extreme environmental conditions.

1N78
1N78A
1N78B
1N78C

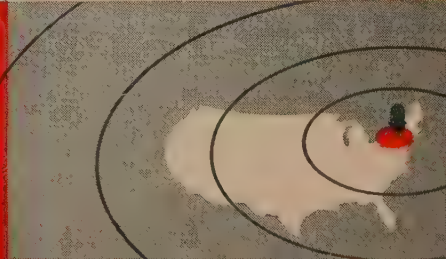
These Silicon Mixer Diodes offer new and unsurpassed performance characteristics to this established family designed for maximum sensitivity operation in the 16,000mc region. The new member of this family is unilaterally interchangeable with existing types while incorporating strikingly superior features: conversion loss (L_c) reduced to 6.0db max; IF impedance (Z_{if}) range tightened (400 to 565 ohms); RF impedance (VSWR) reduced to 1.5; temperature range extended (150° C.). Engineered to meet the most demanding military applications, all the members of this series are packaged in a hermetically sealed case.

Write **Special Components Dept. MJ 1259,** *Lansdale Tube Company Division, Philco Corporation, Lansdale, Pa.*

PHILCO

LANSDALE TUBE COMPANY DIVISION

LANSDALE, PENNA.

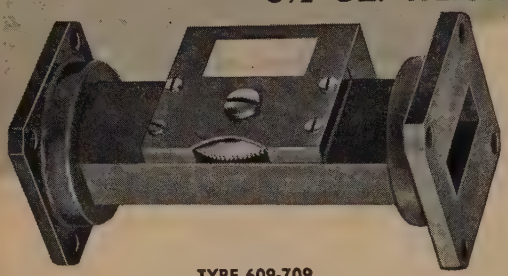


NEW! **MINIATURE LIGHTWEIGHT**

ATTENUATORS

X AND KU BAND ALUMINUM

3½ OZ. WEIGHT



TYPE 609-709

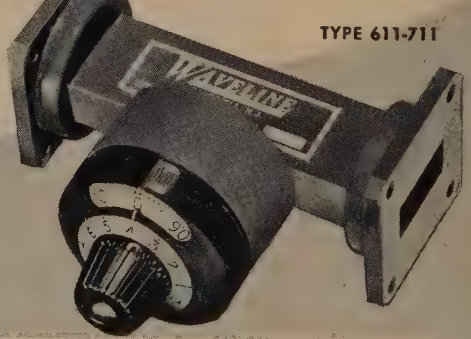
Calibrated 5.0 db points centerband frequencies

TYPE 609-709 are NEW — A small, lightweight, rugged, highly accurate attenuator designed to provide accurate settings under conditions of shock and vibration. The dial can be securely locked. Finish is Iridite. Weight 3½ ounces.

Excellent shielding properties, low 1.15 maximum VSWR value, 0.3 db. maximum insertion loss and a range of 30 db. combine to provide exceptional electrical operation in a small unit.

TYPES 611-711 — The attenuation range of these units is 35 db. calibrated at 9.60 and 15.0 Kmc/Sec. Maximum insertion loss is 0.3 db. with VSWRs not exceeding 1.15. Construction is brass, gold plated.

- **SHIELDED**
- **RUGGED**
- **ACCURATE**



TYPE 611-711

COMPLETE CATALOG AVAILABLE

Type	Unit Price	Frequency Range Kmc/Sec	Attenuation Range	Waveguide Type	Length Inches
609	$50.00	8.2-12.4	30 db	RG-67/U	3.50
709	50.00	12.4-18.0	30 db	RG-91/U-AL	3.50
611	75.00	8.2-12.4	35 db	RG-52/U	3.75
711	75.00	12.4-18.0	35 db	RG-52/U	4.00

LEADERS IN ATTENUATION DEVICES

WAVELINE INC.

CALDWELL, NEW JERSEY

CIRCLE READER SERVICE CARD 7

INDUSTRY NEWS . .

NEW MICROWAVE COMPANY ORGANIZED

The President of Norfolk Precisio Machine Corp., Mr. Joseph L. Traver announces the formation of a new div sion, Precision Microwave Corp. to d sign, manufacture and test microwav systems and components. The new div sion was formed to handle the company increasing microwave business and presently located in a new plant on Mai Street, Millis, Mass.

Precision Microwave division is heade by Mr. Eugene G. Slotta, who was fo the past 7 years with the Raytheon Com pany of Waltham, Mass., as Microwav Methods engineer, founder and Genera Foreman of the Government Equipmen division microwave shop and Genera Shop superintendent of Waltham Plan No. 1 respectively. Mr. Slotta's Micro wave experience dates back to 194 when he was with MIT's Radiation Lab oratory. Mr. Slotta has written severa papers on the art of microwave manu facturing among them, one published b Iron Age Magazine dealing with di brazing of aluminum microwave compo nents.

Mr. David A. Fulton has been ap pointed Chief Engineer of the new firm Mr. Fulton has been in electronics fo the past 14 years, engaged in microwav engineering, production sales and con sulting work. He is a graduate of North eastern University.

Among the growing facilities of Pre cision Microwave are those of aluminum dip brazing and a complete microwav test and calibration laboratory.

Included in the services offered b the new Company are those of manufac turing in either brass or aluminum, de sign and development, and test and ca ibration of microwave components.

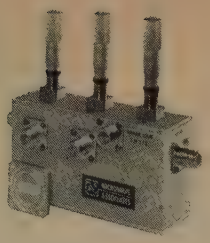
• • •

LITTON ACQUIRES SVENSKA DATAREGISTER

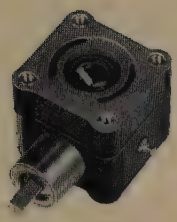
According to an announcement mad today by Litton president Charles H Thornton, Litton Industries and some o the shareholders in Svenska Dataregiste AB have signed agreements whereby Li ton acquires a majority interest in Sven ska. Simultaneously Litton has purchase 100% ownership of two companies, di tributing Svenska's products in USA Mexico and Switzerland. The distributin companies will be administered throug Litton's Monroe Calculating Machin Company Division.

The terms of the purchase were no announced but it is hoped to add mor than $10 million annually to Monroe sales.

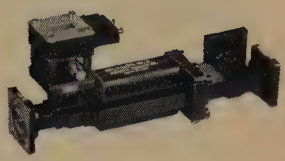
The combined plans of Litton an Svenska for additional manufacturin facilities in Stockholm and for expansio of electronic research and developme facilities there will now be accelerate the announcement reported.



New parametric amplifiers for 4 to 14 db improvement in receivers operating within the 100-1500 mc range.



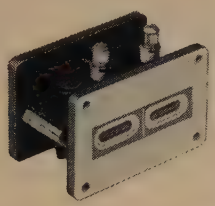
New ruggedized magnetrons for increased reliability of air-borne systems.



New ferrite duplexers, isolators and circulators for advanced systems.

New computer diodes with recovery times lower than 4 mμ secs.

New Varactor diodes that reduce receiver noise to as low as 1 db.



New duplexer tubes that guarantee crystal protection up to 1000 hours and at elevated temperatures.

New solid-state limiters that protect receivers without external bias.

PROGRESS AT MICROWAVE

has a unique 12-month pattern . . .

This pattern of progress at Microwave Associates during the past 12 months reveals a unique combination of solid state and microwave competence. It shows a new-development pace unmatched by any other single source in the microwave field. It promises that your own microwave system planning can benefit from close cooperation with our skilled team of physicists, metallurgists and engineers. Let's move ahead *faster . . . together!*

For data and prices on any of these new products . . . or for engineering cooperation in developing systems components for your specialized needs, write or call:

MICROWAVE ASSOCIATES, INC.

BURLINGTON, MASS. BRowning 2-3000

CIRCLE READER SERVICE CARD 8

DR. JERROLD R. ZACHARIAS

DIRECTOR, Laboratory For Nuclear Science Massachusetts Institute Of Technology

TRADITIONALLY GREAT AMERICAN scientists and engineers have had an early enthusiasm for mechanical contrivances and chemistry sets, coupled with a strong desire to go to some famous engineering school. By these standards Jerrold Zacharias began his career auspiciously. On the one hand he reveled in dissecting mechanisms and doing experiments with a mail-order chemistry set; and on the other he wanted to go to M.I.T. He finally did — but it took 35 years.

His family lived in Jacksonville, Florida. His grandfather had been a tobacconist and his father, never having had the chance to attend college, had read law in a lawyer's office and was a self educated and well educated man. His mother came from New Orleans and although she was stage struck, she learned to play the violin. Years later, after the death of Prof. Zacharias' father, she started teaching the violin at the age of 50 — and taught until her death 28 years later. He had an older sister and an adopted brother — six years older — who was a wonder child pianist. "Do you have any idea of what it is like to live with a wonder child pianist in the house? As a result I tuned out music from my entire consciousness — as if I had earlids which I had closed — until the age of 30. Then I started listening again."

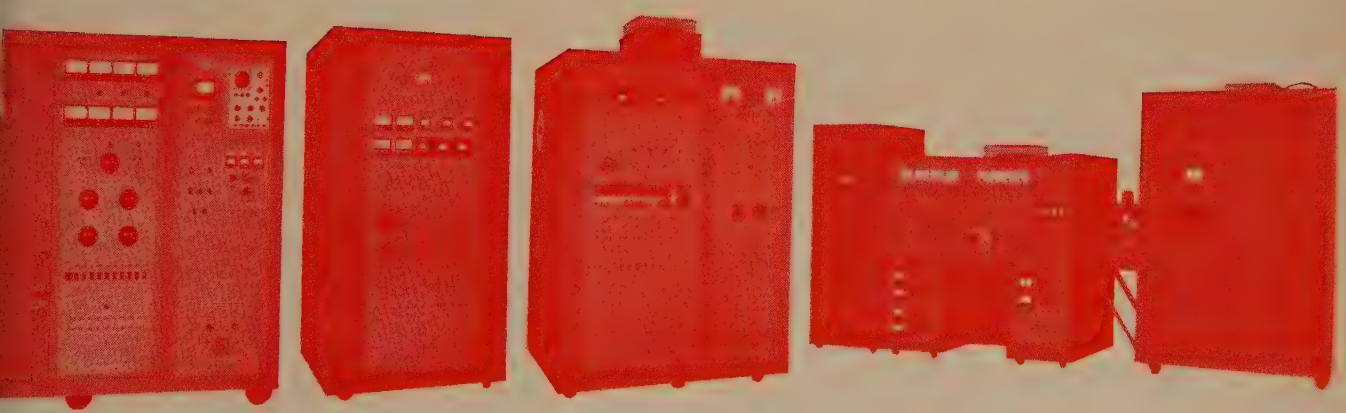
The only college student Zacharias knew in Jacksonville was studying electrical engineering at M.I.T., and although he thought he wanted to be an engineer — the idea of physics hadn't occurred to him yet — his mother urged a well rounded education. So, at 17, he completed high school, moved to New York, and entered Columbia as a pre-engineering student.

"I was not a student," he insists, "I didn't study and I don't know what I was interested in." Feeling it was the thing to do, he joined a fraternity but it did not work out well. He found he was in a group of men with whom he had almost no interests in common. "I would have been much better off if I had been allowed to drift for a year instead of getting involved with a number of embryonic lawyers with no deep intellectual interests and certainly no scientific interests." He found the pre-engineering work dull and the undergraduate courses he took in physics did not reveal a subject of any interest. And he feels this is still a common occurrence. "I only got interested in learning with a capital L when I learned that physics was something you could do." And this he learned from a graduate student named I. I. Rabi. They often took long walks, talking of the problems and prospects of a field that was at that time little more than a curiosity — only two people in his class were seriously interested in physics. His association with Rabi produced a lifelong friendship and a lifelong habit: "It is still true that both he and I do our best work while talking, and when we are talking to each other we are really at our best." And it decided his life's work. For the first time he felt that he was really headed somewhere. In those early years he counseled his mother — when her friends asked her what a physicist was — to explain it as "Kind of a chemist, only it doesn't smell so bad."

And it was at Columbia, during his junior year, that he met Leona Hurwitz, a biology major at Barnard. He graduated in 1926 and married her in 1927. They both continued studying for masters and doctoral degrees. "When the so-called depression years came, she supported me while I took my Ph.D. and then she supported both of us while she took hers." Mrs. Zacharias has always been active in her field and is doing research at the Massachusetts Eye and Ear Infirmary on retrolental fibroplasia, a disease in prematures.

With a child on the way, he took a teaching job in 1932 at Hunter College a year before finishing his Ph.D. in solid state physics. Between his teaching and the laboratory research he went into after graduation, he worked 50 to 60 hours a week. The lack of routine made such a load bearable. "The only thing I did very poorly was correcting papers — anything else was all right because I could talk. Up until when I started to teach I was extraordinarily inarticulate to the point of being taciturn but when I had to teach I had to talk and that made all the difference." He worked under Rabi in the molecular beam laboratory for seven years developing new methods of molecular beam magnetic resonance. In 1944 Dr. Rabi won the Nobel Prize for the work done with his group on the magnetic properties of atomic nuclei.

(*Continued on page 14*)



LEVINTHAL ELECTRONIC PRODUCTS

SUBSIDIARY RADIATION INC

STANFORD INDUSTRIAL PARK PALO ALTO 7, CALIFORNIA

EQUIPMENT DIVISION

CIRCLE READER SERVICE CARD 9

(*Continued from page 12*)

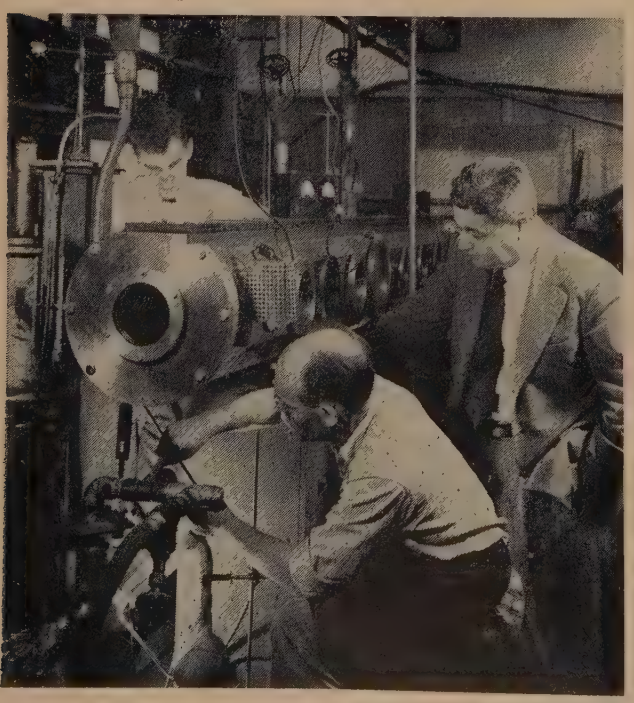
In the fall of 1940 he was appointed a staff member of the newly created M.I.T. Radiation Laboratory at the instigation of Lee DuBridge. He remained there four years working primarily on the transmission of centimeter waves in microwave radar systems. "I came up about three weeks after it started and I felt I never did catch up."

He went to Los Alamos just before the end of the war and spent several months running the engineering division. He came back to M.I.T. as a Professor of Physics in 1946 and brought with him, at the urging of Prof. John Slater, a group of accomplished physicists to set up the Laboratory for Nuclear Science. Prof. Zacharias directed the laboratory for 10 years and finally turned it over to Prof. Martin Deutsch. "Enough is enough. One reason was that the whole tenor of physics was going from nuclear physics into very high energy particle physics and my own researches were far away from that."

One thing that characterized much military research work, and with which Prof. Zacharias has repeatedly come to grips, was the anticipation of needs in technical instruments: to have them ready before there was any general recognition that they would be necessary — and often essential — to the war effort. "I remembered installing the first microwave radar on a destroyer in 1941 before Pearl Harbor. The admiral came on board and said 'What's this stuff for — I want something to fight World War II with, not World War III.' But it was microwave radar that saved the Navy in the Pacific."

"In 1948 I was sitting quietly in my office and was approached by Jim Fisk — then director of research of the Atomic Energy Commission — on how the AEC could get a straight story on the subject of nuclear powered flight. He said it was impossible to get the old team of physicists together to work on problems of this sort. I looked him straight in the eye and said: 'Jim, have you ever tried paying them?' He said 'no.' I said 'Try it.' That question was the origin of a whole series of summer studies."

Dr. Zacharias watches a technician install the vacuum system in the "molecular beam" apparatus used in studying the magnetic properties of the atomic nucleus.



Dr. Zacharias discusses an experiment with an MIT graduat student.

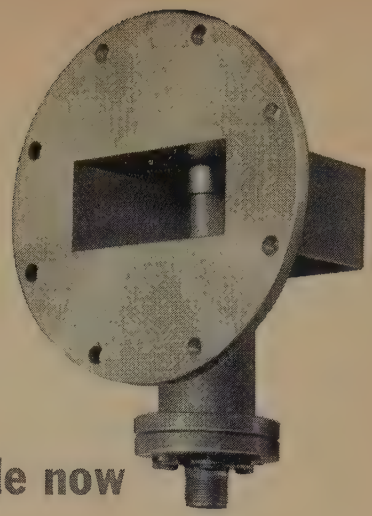
And the 1948 study of nuclear powered flight, calle Project Lexington and for which he was associate directo was the first of a series of summer studies and project he became involved in. He was director of Project Hart well, dealing with undersea warfare, in 1950; associat director of Project Charles on air defense in 1951; an associate director of Project Lincoln in 1951 and 1952 out of which came the M.I.T. Lincoln Laboratory and th SAGE air defense system. He helped initiate and the directed the Summer Study of 1952 on the Distant Earl Warning Line. The project was set up over the objection of many people. It proved successful and the first demon stration of automatic radar occurred in a rather unusua way:

"Military installations suffer from a kind of cance which I call 'Cooks for the motor pool and motor poo for the cooks.' And in the arctic, where the DEW Lin had been installed, this was intolerable. So in our warning system we needed not only organization and communica tions, but we needed to detect aircraft automatically so that a man who cooked breakfast and slept and polishe the stove and wrote letters home could operate a radar site This means that the radar signals had to be taken off automatically. Smullin and I had found in the lab, fo another purpose, a way to get automatic signals which could be converted into an alarm. In order to demonstrate this at the conclusion of the study — which was never officially recognized and only called the Summer Study o 1952 — Herb Weiss of Lincoln Lab set up a radar on top of Building 20 at M.I.T. We piped the signals via telephone wire to the penthouse of the Sloan Building where we were having a meeting of about 100 people consisting mostly of generals and admirals and high De fense Department civilians. We fed the signals through a loudspeaker which was directed towards a little toy dog house that was rigged so that when there was a noise, a little dog name Sparky would jump out. So I said 'Here is my attendant' and I took the cloth off the doghouse and waited for an airplane from Logan Airport to go by. Almost immediately there was a sort of deep burp and Sparky jumped out. That was the first automatic radar."

In 1954 he was the technical director of Project Lamp Light which dealt with continental air defense by the Navy. And in 1955 he received the Department of De fense Certificate of Appreciation — its highest civilian honor — for his work.

(*Continued on page 17*)

SMALL APPETITE NOISE SOURCES



service-proved and available now

Until recently signal simulators for monitoring radar receivers or microwave relays were of two types. One was a big and heavy ampere eater with cumbersome auxiliary equipment; and the other was a sensitive though delicate instrument suitable only for the laboratory.

We call your attention now to the Litton 2000 series of miniature gas noise sources. The Litton 2000 for waveguide use is pictured above. It has a first cousin, the Litton 2007 designed for coaxial cable use. We call your attention because most tubes in this series are now in production and we suspect there are frustrated design engineers who will receive this announcement with keen interest.

Our gas noise sources may properly be called miniature. They require only inches of space, smaller, lighter auxiliary equipment, and small voltages and currents. Around 500 volts fires them; 100 milliamperes maintains them. These characteristics, plus others, have caused them to find numerous applications: for in-flight calibration and test of aircraft microwave receivers; as *automatic* watchdogs on airborne radar systems; and in other systems which require various immunities to vibration, shock, humidity, and temperature cycling.

The Litton family of miniature gas noise sources, like all Electron Tube Division products, was designed to solve specific end item functions. We have found that this philosophy contributes to consistent reliability: tubes do their jobs more efficiently, for longer periods of time, and at lower overall cost to the buyer. Other advantages also result. For example, these noise sources require *no* ageing-in and the L-2000 is replaceable in the field without changing the mount.

Specific frequency ranges in L, S, C, X and K bands are covered. If you are concerned with radar transmission, or with microwave data links of any kind, we'll gladly send you more information. Write to Litton Industries Electron Tube Division, Salt Lake Plant, Office M9, Salt Lake City 10, Utah.

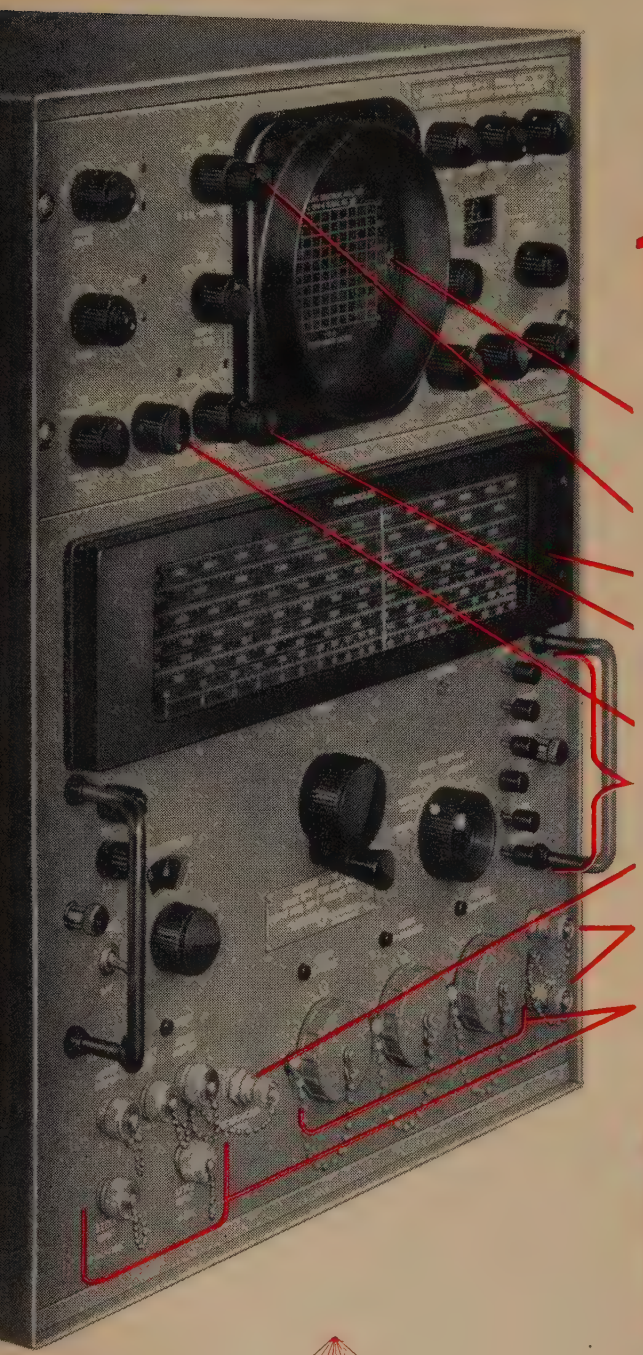
CIRCLE READER SERVICE CARD 10

LITTON INDUSTRIES Electron Tube Division

BARRATRON TRANSMITTING TUBES • MAGNETRONS • KLYSTRONS • TRAVELING WAVE TUBES • BACKWARD WAVE OSCILLATORS • CARCINOTRONS • GAS DISCHARGE TUBES • NOISE SOURCES • CROSSED-FIELD AMPLIFIERS • HIGH DEFINITION CRT • DIRECT-WRITING CRT • STORAGE TUBES • MICROWAVE FILTERS • DUPLEXERS • TR TUBES

CAPABILITY THAT CAN CHANGE YOUR PLANNING

more exclusive advantages for applications demanding extreme sensitivity, stability, versatility



PANORAMIC'S SPA-4 SPECTRUM ANALYZER

10 mc to 44,000 mc

CHECK THESE IMPORTANT FEATURES:

THREE PRECISELY CALIBRATED AMPLITUDE SCALES — 40 db log, 20 db linear, 10 db power — for simultaneous measurement of signals having large or small amplitude differences and for reliable power point measurements. Front panel control selects scale.

CAL—SYNC SELECTOR simplifies sweep rate settings from 1 cps-60 cps to any submultiple of power line frequency.

ONE TUNING HEAD — 10 mc to 44,000 mc. Direct reading frequency scale with ±1% accuracy.

TWO INDEPENDENT FREQUENCY DISPERSION RANGES: Continuously adjustable; 0-70 mc for wide band investigations. 0-5 mc for extremely stable narrow band analysis. **Negligible Internal Frequency Modulation** permits extremely narrow band analysis free of FM problems.

VARIABLE I.F. BANDWIDTH 1 KC TO 80 KC for analysis of wide or narrow pulsed r.f. signals.

PUSH-BUTTON FREQUENCY RANGE SELECTOR. Automatically couples proper mixer and oscillator of desired band, illuminates applicable input connector and slide rule dial calibrations.

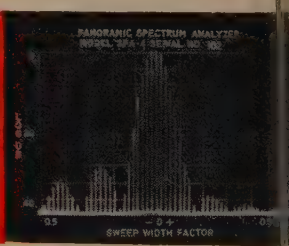
SYNCHROSCOPE OUTPUT WITH 40 DB GAIN for observations of input signal envelopes.

ACCURATE MEASUREMENT OF SMALL FREQUENCY DIFFERENCES. A self-contained marker oscillator, modulated by a calibrated external generator, provides accurate differential marker pips as close as 10 kc.

WAVEGUIDE INPUT CONNECTORS for 10.88 kmc to 44 kmc and type N connectors from 10 mc to 10.88 kmc.

PANORAMIC'S SPA-4 PROVIDES EXCEPTIONAL USABLE SENSITIVITY

BAND	RF SENSITIVITY*
1- 10 — 420 MC	—95 to —105 dbm
2- 350 — 1000 MC	—90 to —100 dbm
3- 910 — 2200 MC	—90 to —100 dbm
4- 1980 — 4500 MC	—80 to —95 dbm
5- 4.5 — 10.88 KMC	—80 to —95 dbm
6- 10.88— 18.0 KMC	—70 to —90 dbm
7- 19.0 — 26.4 KMC	—60 to —85 dbm
8- 26.4 — 44.0 KMC	—55 to —85 dbm



*measured when signal and noise equal 2x noise

Analysis of pulsed signal on Model Sweep rate here was synchronized PRF to show the individual spikes

Tremendous flexibility and many unique advances of Panoramic's compact SPA-4 make it unsurpassed for visually analyzing FM, AM and pulsed signal systems; instabilities of oscillators; noise spectra; detection of parasitics; studies of harmonic outputs; radar systems and other signal sources.

Write, wire or phone today for detailed SPA-4 specification bulletin.

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dependable **CERTIFIED SPECIFICATIONS** *for accurate data*

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Dr. Jerrold Zacharias

(*Continued from page 14*)

In addition to running the nuclear lab, teaching, and participating in various study groups, he was busy with his own researches. "One characteristic of the way I work is to keep several things going in parallel — except for short spurts." One outgrowth of his studies of the electric and magnetic shape of atomic nuclei — and incidental to it — was the perfection of the atomic clock. He regards this as a good example of how it is possible to go directly from laboratory work to something the military want. It is correct to one part in 10^{12} or a million million and is the most accurate and stable clock in commercial production. The National Company for which he is a consultant, is producing the clock. With Prof. Jerome Wiesner he made another venture into the business world and set up the Hermes Electronic Company to provide ". . . a more lucrative outlet for some of our military technological ideas."

He was called to testify twice at the Oppenheimer hearings — which he regards as partly an outgrowth of the McCarthy investigations — and both times supported Oppenheimer exceedingly strongly. "I believe that the McCarthy era was like a sort of overdone typhoid innoculation in which the patient almost dies but is a hell of a lot better off for the innoculation. This doesn't mean that I believe McCarthyism is dead — there are too many wealthy and bigoted men of power who backed him to believe that the whole disease was killed. But at least we're on guard. It was a horrible thing."

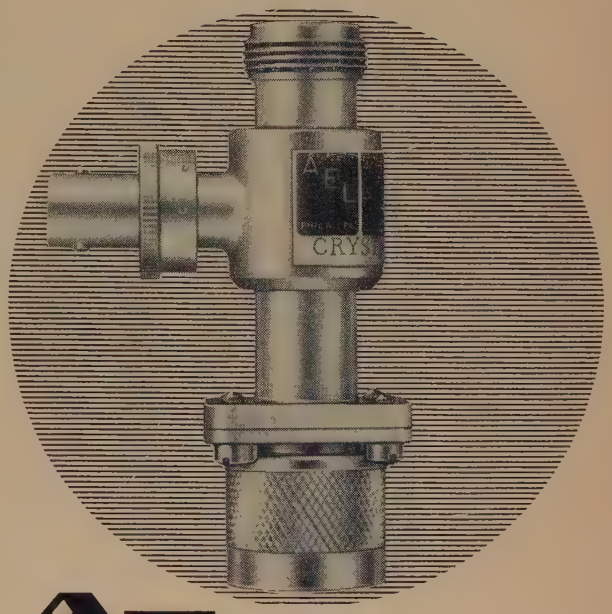
As a result of frequent briefings on the rapid technological progress being made by the Russians — and the possibility of our someday falling behind — which were given while he was a member of the President's Science Advisory Committee, he sent a memorandum to Dr. Killian. It suggested an experiment using moving picture aids and special texts to improve physics teaching in high schools, emphasizing that the most important thing to do was ". . . to get the subject of physics really right and really interesting." Out of this grew the Physical Science Study Committee which, backed by tremendous support and enlisting the aid of educators, scientists, teachers, and students all over the country, is now completing an entirely new approach to teaching physics. Already being given to thousands of students with encouraging results, he feels that it is well on the way to being one of his biggest and most successful experiments. He feels the next move will be to do the same thing on the college level. "But this is the last project I direct — and I sincerely mean that. On the next project I am willing to work but I am not willing to be a director or an associate director."

The future holds two specific projects — both extensions of what has gone before. He wants to perfect the technique of mass teaching — he has lectured successfully to 1500 students using movies and optical projection — and he plans to continue working on clocks: ". . . fancier clocks, bigger and better clocks. And," he adds, "Perhaps a few nuclear problems."

Several years ago a hurricane passed over Buzzards Bay at the edge of Cape Cod, and its damage included the removal of part of a bluff in front of a large 20 room house on a bit of land called Toby's Island. The house had been empty for a few years and Prof. Zacharias, wanting some place to go during summers, took it over. Toby's Island is rather tenuously connected to the mainland by a

(*Continued on page 20*)

a NEW CONCEPT in MICROWAVE SWITCHING



AEL®

MICROWAVE COAXIAL CRYSTAL SWITCH

CLOSED INSERTION LOSS AS LOW AS ½ db

A new concept in microwave switching developed at the American Electronic Laboratories, Inc., has resulted in the Microwave Coaxial Crystal Switch. Closed insertion loss as low as ½ db. Open attenuation 20 to 30 db increased by series connection of switches if desired. The extremely low power requirement of as little as 16.5 milliwatts and high switching speeds of over 10 millimicroseconds make this switch a natural for high speed antenna lobe switching, microwave chopping for crystal video detection of RF, high speed commutation, and also as a high speed switching device for computers. Additional characteristics are its virtual independence of its switching characteristics to temperature over a range from —55° to +71°C., its ability to dissapate up to 1 watt of power internally and its high degree of reliability.

MORE DATA ON REQUEST

Investigate the opportunities at AEL for creative engineers

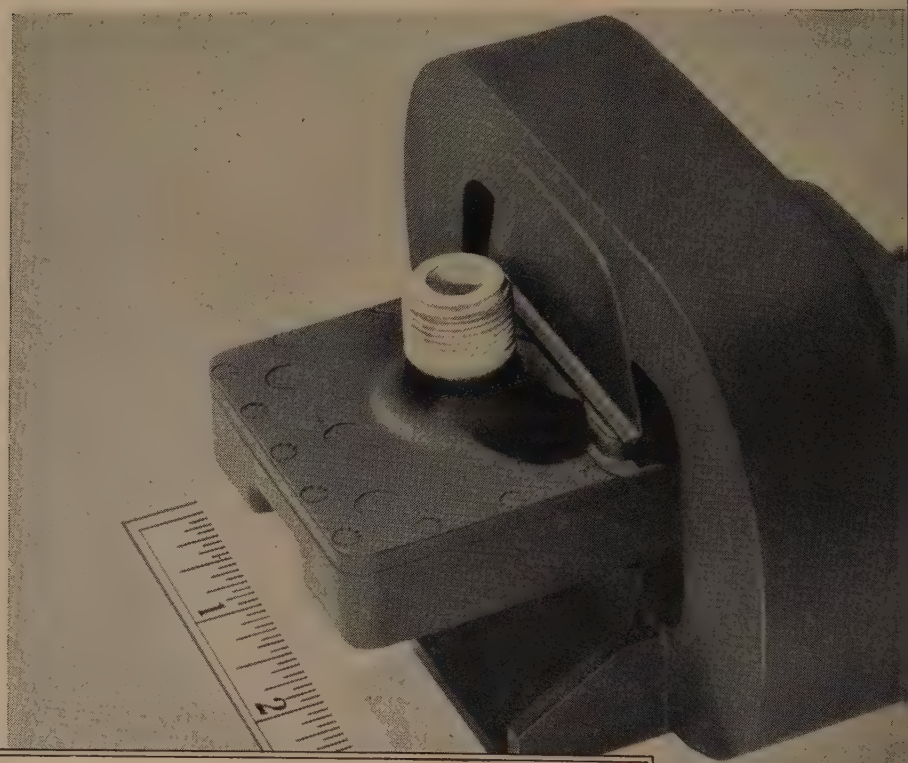
AEL AMERICAN ELECTRONIC LABORATORIES, INCORPORATED

121 N. 7th ST., PHILADELPHIA 6, PENNA.

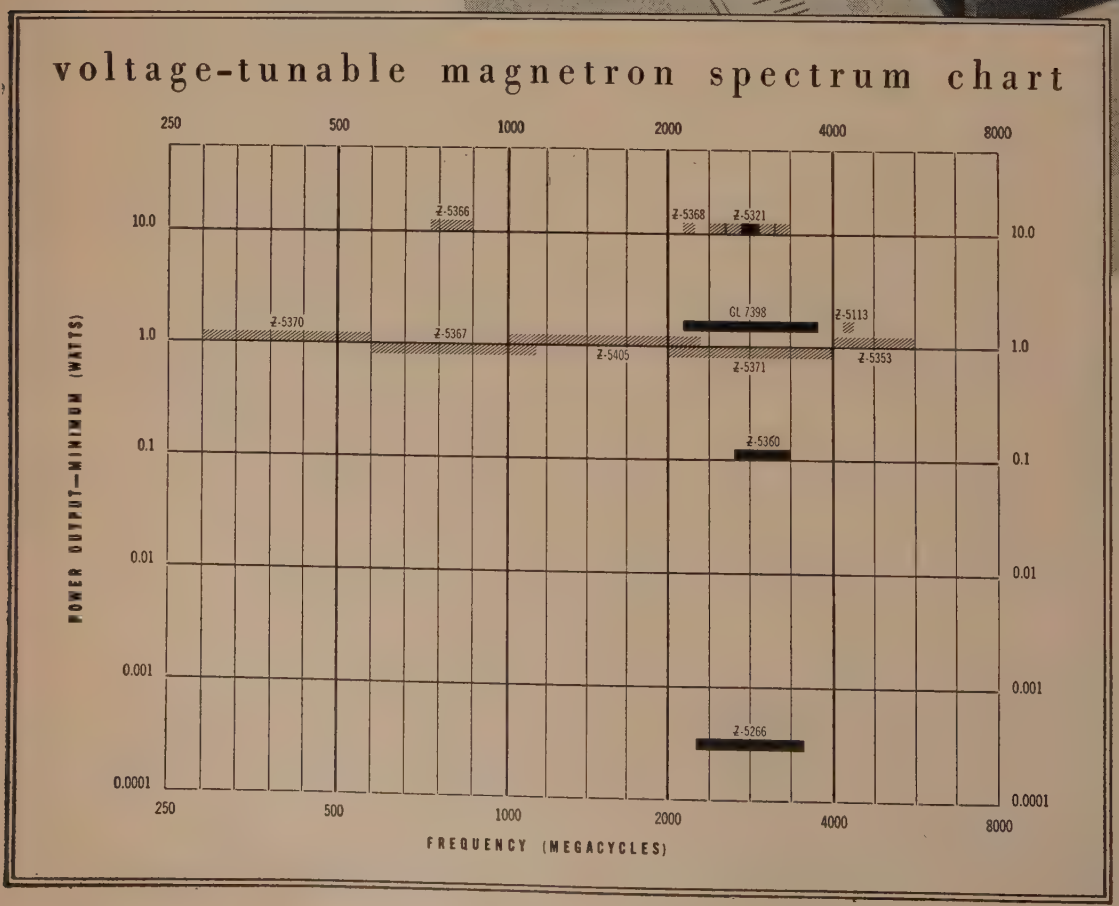
In Canada contact: Conway Electronic Enterprises Regd., Toronto, Canada

CIRCLE READER SERVICE CARD 12

GENERAL ELECTRIC GL-7398 VOLUME PRODUCTION, AVAILABLE



Voltage-tunable magnetrons now available are indicated by solid areas. Other developments are shown by cross-hatched areas.



VOLTAGE-TUNABLE MAGNETRON IN FOR IMMEDIATE DELIVERY!

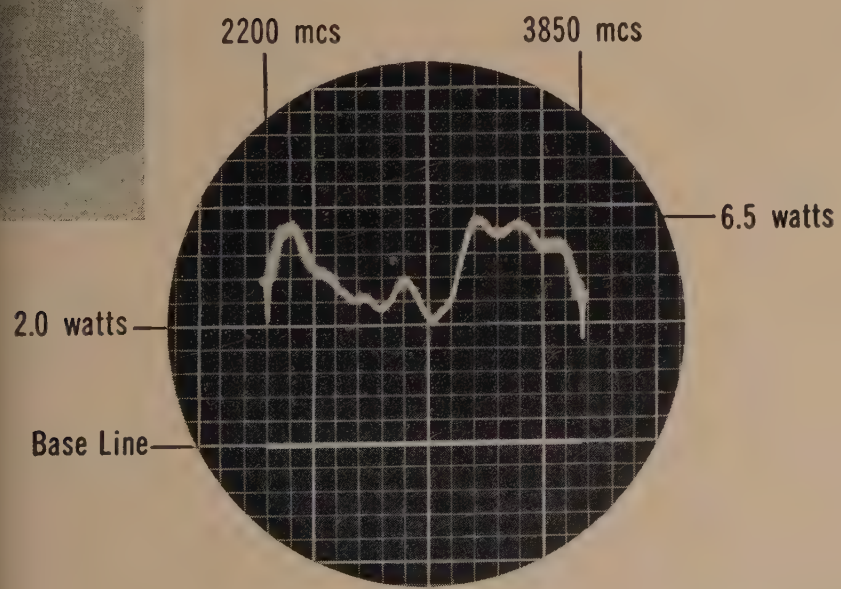
The General Electric GL-7398 voltage-tunable magnetron, a complete RF power source ideal for FM modulation, is now in volume production and available for immediate delivery. Moreover, samples are currently available or can be developed by use of proved technology to meet any need within the frequencies charted on the opposite page. The GL-7398 is designed for use in many applications, such as:

- FM telemetering or video transmission
- Beacon transmitters
- Local oscillators in electronically tunable radars
- Drivers in pulse-to-pulse frequency-shift radars
- FM altimeters
- Broad-band signal generators
- Countermeasure transmitters
- Drivers for countermeasure amplifiers

Output frequency can be varied linearly over a range of nearly 2 to 1 by sweeping the anode voltage. Power output is relatively flat at a minimum of 2 watts. The GL-7398 is a rugged, compact, packaged unit with these characteristics:

Anode voltage at 3 kmc	— 1250 volts
Anode current	— 10-20 ma
Frequency range	— 2200-3850 mcs
Tuning rate	— approx. 3 mcs/volt
FM rate	— 10 mcs or higher
Weight	— 3.1 lbs.

By use of internal narrow-band circuits, a variation (Z-5321) is available which gives a minimum of 10 watts power over a 200 mc bandwidth at a factory-predetermined centerpoint in the 2 to 4 kmc band. Other variations with built-in attenuators for local oscillator applications can be supplied (Z-5360 and Z-5266). *Power Tube Department, General Electric Company, Schenectady, New York.*



◀ Typical power – frequency of the GL-7398 shows power constant over the full band to within plus-or-minus 3 db.

Progress Is Our Most Important Product

GENERAL ELECTRIC

9545-8481-2

NEW FROM NARDA

MICROWAVE MODULATOR

accepts over 40 magnetrons!

Here's the first of a series of new products from Narda's recently-established High Power Electronics Division! A high power Microwave Modulator that permits installation **inside the unit** of any of more than 40 magnetrons! Complete, compact and self-contained, it accepts magnetrons covering 3,200 mc to 35,000 mc, with peak outputs from 6 KW to 120 KW. Model 10001 features a completely interlocked circuit, with all high voltage leads and connections **internal,** for maximum safety; solid state high voltage bridge rectifiers for longer life and reduced heat output (prolonging life of other components, too); and built-in meters and viewing connectors for all principal parameters.

Other features are shown below. For complete specs and a list of at least 40 magnetrons suitable for use with the 10001, write Narda's High Power Electronics Division (HPED) at Dept. MJ-7.

SPECIFICATIONS

High voltage supply: Continuously variable from 0 to 4 KV at 100 ma; **Pulse power:** 18 KV at 20 amps max.; **Magnetron filament supply:** Cont. variable from 0 to 13 volts at 3 A; **Rep. rate generator range:** Cont. variable from 180 to 3000 pps; **Pulse width:** 1 microsecond at 70% points, rise time 0.15 microseconds, max. slope 5% (other pulse widths available); **Size:** 38" h, 22" w, 18" d. **Weight:** 150 lbs.

Complete 1959 catalog available on request.

the narda microwave corporation

HIGH POWER ELECTRONICS DIVISION

118-160 HERRICKS ROAD, MINEOLA, L. I., N. Y. • PIONEER 6-4650

(*Continued from page 17*)

rickety bridge and an insubstantial causeway. "Peop often ask me if I shouldn't have consulted with a meteor ogist before buying the house," he says referring to t havoc wrought by the hurricane, "And I reply that bought it from one." The house has been slowly ma over — a salty Cape Cod carpenter has been at it three and a half years — and there is still a good deal l to do. "Leona and I like to build, but not new hous Restorations, like this, we enjoy." For a month during t summer and on many weekends, he and Mrs. Zachar drive down in a Volkswagen from their Belmont hom Their younger daughter Johanna, rather precocious at is often with them. Their older daughter, Susan, is m ried and lives in Rochester, N.Y. — where her husband a professor of Physics, too.

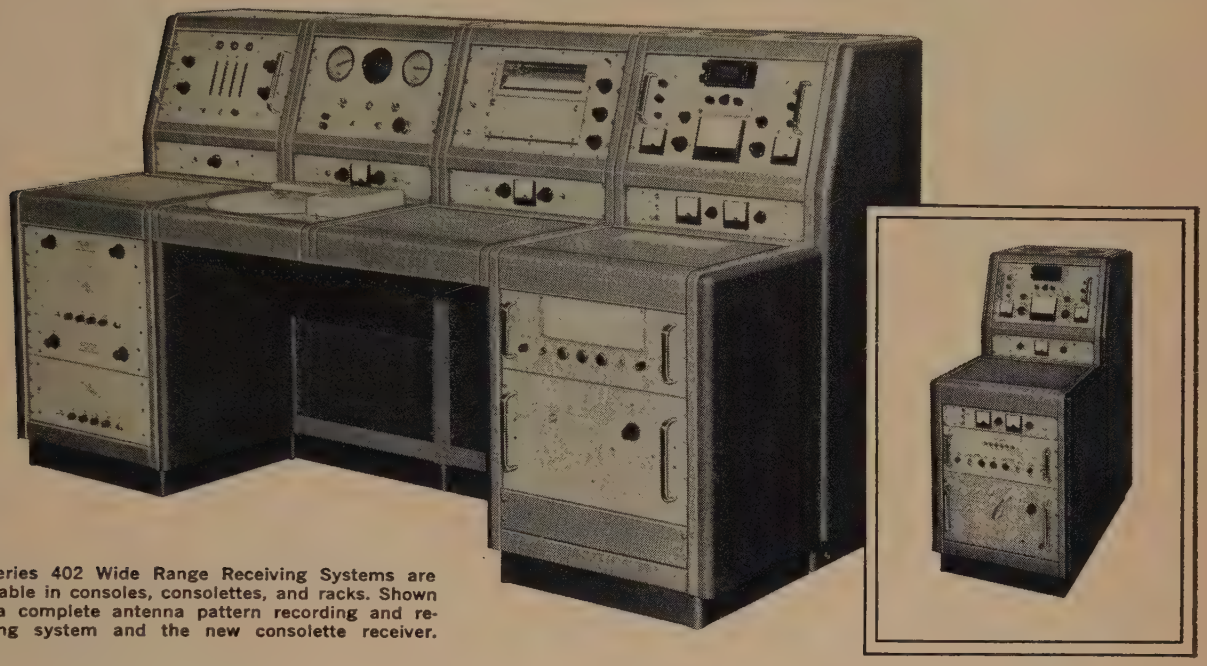
Walking along the edge of the water Prof. Zachar points out the breakwaters he is putting in. "People cla I like to buy things by the case, so they describe this a case of breakwaters." A Zacharias-designed dock h been built near a refurbished boathouse and two skif inexplicably called the "D. H. Lawrence" and the "Nels Rockefeller," are tied near it. A kitten-class sailboat nam "Wildcat" is anchored a bit further out. "I am thinkin of renaming the sailboat — I'll turn the "W" in Wildc upside down." Two exuberant poodles, Lorenzo and H pageno, have the run of a large fenced-in area includi the house. Facing west across the bay is a long front por with Zacharias-designed pillars supporting the roof whi are hollow and open at the back with a series of shelves t size of dinner plates and are ". . . large enough for a go shadow, and small enough so they don't spoil the view He enjoys an occasional whimsical or clever contrivan and on one of the shelves is a toy elephant which, wh wound up, dips his trunk in a tiny pail in front of hi flaps his ears, and happily blows small clouds of so bubbles all over the porch. The elephant does not appear be connected to a radar system.

He enjoys relaxing on the porch, sometimes reading b more often peering at local bird life through powerf binoculars and watching for some favorite coots — a ki of sea duck — who are regular visitors. "I'm not a hobbyi I don't like detective stories and I can go for mont without looking at a newspaper. I'm very happy readi a book like this," — picking up Barzun's *The House the Intellect* — "And I like some listening. But I like good argument more than anything. We try not to spe all our time with physicists, and our friends include lawye social scientists, journalists, movie people. I love to down and talk with anyone who has some ideas. But suffer fools very badly. I regard the truth as so importa than even withholding some of it, be it ever so painf obnoxious, and annoying, is something I take no refu in. But I do have one virtue: I like to have around people who are much brighter than I. This is easy. A it is very effective."

He is insistent upon his lack of enthusiasm for t ditional hobbies and relaxations. He prides himself being lazy — but by lazy he usually means doing as ma things as possible simultaneously with the minimum effo his laziness partakes more of efficiency than indolen "I'm perfectly willing to run a dozen things but I'm a willing to sit and look at the coots. There are no ru about what I like to do — but most I like to sit a count coots."

MAJORS and MINORS

...A Message to the Antenna Designer



● Series 402 Wide Range Receiving Systems are available in consoles, consolettes, and racks. Shown are a complete antenna pattern recording and receiving system and the new consolette receiver.

A crowded spectrum plus high power radar and communication systems critically compound the problems of the antenna design engineer.

More than ever, the complete pattern including **all** the major and minor lobes of every radiating element must be graphed for sound engineering evaluation.

S-A Receiver Gets the Whole Signal

Scientific-Atlanta Series 402 Wide Range Receiving Systems are specifically designed for antenna pattern measurements. Unique in design, these receivers combine maximum sensitivity and linearity from 30 mc to above 100 kmc. They are also useful as multipurpose laboratory instruments for microwave testing, monitoring, and measuring applications.

Only from S-A, 1 db Linearity over Full 60 db Dynamic Range

A recent development, S-A's P-4 modification adds 20 db to the normal 40 db dynamic range. The modification takes advantage of the gain vs AGC voltage characteristics of the Series 402. Existing receivers can be modified at the factory.

New Modification Z Broadens Use

Modification Z adds a precision IF attenuator and VTVM to the Series 402. Now RF and microwave signal level, gain, and isolation measurements can be made with fewer components and instruments. *For instance,* an X band 80 db attenuator can be calibrated to within ±0.5 db with a 1 mw signal source, a flap attenuator, a mixer, and an S-A Series 402Z Receiver. Antenna gain can be measured by direct comparison with a standard gain antenna. Signal levels can be compared against a reference standard.

Other Features

One coaxial cable from antenna to receiver eliminates costly lossy waveguides and rotary joints. Antenna can be located up to 75 feet away with negligible loss in sensitivity ☆ One receiving system covers 30 mc to above 100 kmc without plug-ins ☆ Reception of cw signals from simple sources eliminates need for precise modulation ☆ High sensitivity means low source power and long ranges ☆ High selectivity reduces interference and cross talk between adjacent test ranges ☆ Positive AFC action over full dynamic range provides pattern recording in deep nulls.

PRICES

Series 402, 2 to above 100 kmc	$7500
Series 402A, 2 to above 100 kmc with AGC	8000
Series 402B, 30 mc to above 100 kmc	8500
Series 402C, 30 mc to above 100 kmc with AGC	9000
Modification P-4	500
Modification Z	1000

NEW DATA FOLDER READY

For complete information ask for our new data folder from your nearby S-A engineering representative or write directly to Box 6812

SCIENTIFIC-ATLANTA, INC.

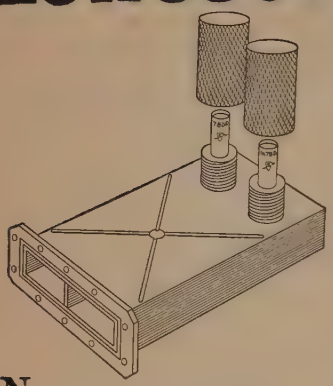
2162 PIEDMONT ROAD, N. E.
ATLANTA 9, GEORGIA
PHONE: TRinity 5-7291

3

CIRCLE READER SERVICE CARD 15

Microwave Component News from SYLVANIA

Lowest receiver noise figure yet via new Ku Band Diodes



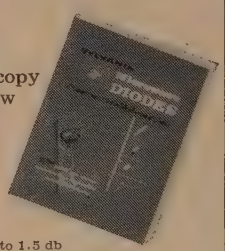
NOW SYLVANIA has new Ku band silicon microwave diodes, types 1N78D and 1N78DR, with a 7.5 db maximum over-all noise figure* for mixer applications.

Extremely low noise figure for Ku band receivers is now possible with a new silicon microwave mixer diode developed by Sylvania, and available in both forward and reverse polarities. When the 1N78D and 1N78DR microwave diodes are used as a matched pair, they virtually eliminate excess noise due to the local oscillator, thus providing a receiver system with a realistic 7.5 db over-all noise figure at Ku band. The use of the matched pair also serves to effectively isolate the antenna and local oscillator terminals.

The new microwave diodes also feature a maximum operating temperature of 150°C as well as a complete hermetic seal for maximum protection under severe environmental conditions.

Contact your Sylvania representative now for complete information on these new low noise Ku band diodes or write the factory directly at the address below.

Write for your free copy of this completely new Sylvania Microwave Diode Characteristics and Replacement Guide.



*with IF amplifier NF equal to 1.5 db

BASIC SPECIFICATIONS OF NEW 1N78D AND 1N78DR DIODES*

Operating Temperature		150°C max.
NOISE FIGURE (CALC) N=LC (NIF+NR-1) where NIF=1.5 db	NF	7.5 db max.
CONVERSION LOSS P=1.0mw, F=16,000 mc JAN-201 holder	LC	5.7 db max.
OUTPUT NOISE RATIO P/1=0.5 MADC (min), F=9375 mc JAN-105,202 holder	NR	1.3 times max.
IF Impedance	Z_{IF}	400-565 ohms.
RF Impedance	VSWR	1.5 max.
Moisture Resistance		All units are hermetically sealed and pass MIL-STD-202 Method 106 Moisture Test.

*available also in matched pairs designated 1N78DM and 1N78DMR. Matching criteria are conversion loss within .3 db and IF impedance within 25 ohms of each other.

SYLVANIA GENERAL SYSTEM

Subsidiary of GENERAL TELEPHONE & ELECTRONICS

SYLVANIA ELECTRIC PRODUCTS INC.
Semiconductor Division
100 Sylvan Rd., Woburn, Mass.

INDUSTRY NEWS

PACKARD RESIGNS FROM VARIAN BOARD; ZINSER ELECTED SUCCESSOR

David Packard's resignation from V rian Associates' board of directors w announced today by board chairman D Edward L. Ginzton who said mountin pressures of other duties prompted Pac ard's decision to terminate his long a sociation with Varian.

In accepting Packard's resignation, D Ginzton expressed the company's regr on the loss of his services and also h appreciation for Mr. Packard's significa and important participation in Varian a tivities as a member of the board sin July, 1949, and for his strong influen in the formulation of company policie

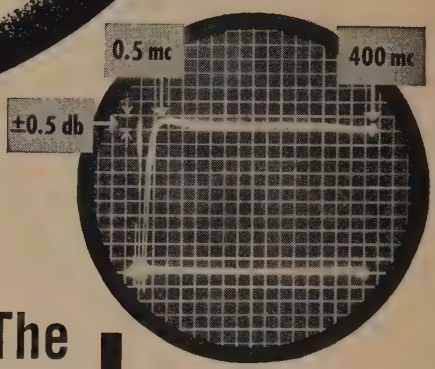
Packard's resignation created the se ond vacancy on Varian's board of d rectors, the other having occurred wi the death, July 28, 1959, of Russell V rian, a company founder and boa chairman at the time of his death.

At their regular meeting, October 2 Varian's board of directors elected Mer Zinser, vice president, finance, to f one of the two vacancies and indicat they are considering several candidates fill the remaining vacancy. An announc ment is expected soon.

Merle Zinser

Mr. Zinser joined Varian Associates 1951 after several years with Marcha Calculating Company as assistant to t president. He has been responsible f organizing Varian's financial operatio and arranging for financing its grow from a company with annual sales under $2 million in 1951 to over $ million for 1959.

Zinser's previous business connectio include posts with General Motors Cor oration, United States Steel Corporatio Peat, Marwick, Mitchell & Co., Cert fied Public Accountants, Talon, Inc., a Pabco Products. He received his B in business administration and economi from Indiana University. Mr. Zinser a member of the Controller's Institu of America.



JERROLD'S *versatile new*

900A Sweep Generator Covers The Range of Three Regular Instruments!

It's the most *versatile* Sweep Generator in the electronics industry... this one instrument covers *all* your needs from ½ MC to 1200 MCS, for **IF's, radar, video, telemetering and communications!**

Specifications: In two ranges—0.5 MC to 400 MC and 275 MC to 1200 MC—the instrument supplies a sweep signal with center at any frequency from 500 KC to 1000 MC and with sweep widths as broad as 400 MC and as narrow as 100 KC. The RF output—carefully monitored by matched, crystal diodes feeding a two-stage, push-pull AGC amplifier—is flat within ±0.5 db at full sweep width up to 800 MCS and ±1.5 db from 800 MCS to 1200 MCS. When using sweep widths as narrow as 20 MCS flatness at any center frequency is approximately ±0.15 db. **$1260.00**

- **HIGH OUTPUT!**
  .25 volt RMS on VHF—
  .5 volt RMS on UHF!
- **WIDE SWEEP WIDTHS!**
  From 100 KC up to 400 MCS!
- **FLAT OUTPUT!**
  Flat to ±.5 db on *widest* sweep width!

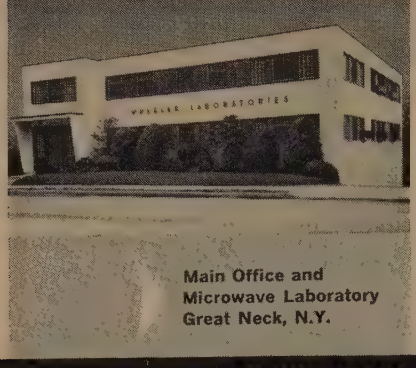
NOW . . . FULL PRODUCTION ASSURES FAST DELIVERY!

Write today for on the spot demonstration of this versatile instrument!

JERROLD ELECTRONICS CORPORATION *Industrial Products Division*
Dept. TED 56 The Jerrold Building Philadelphia 32, Pa.

Jerrold Electronics (Canada) Ltd. • *Export Representative, Rocke International, New York 16, New York*

CIRCLE READER SERVICE CARD 17



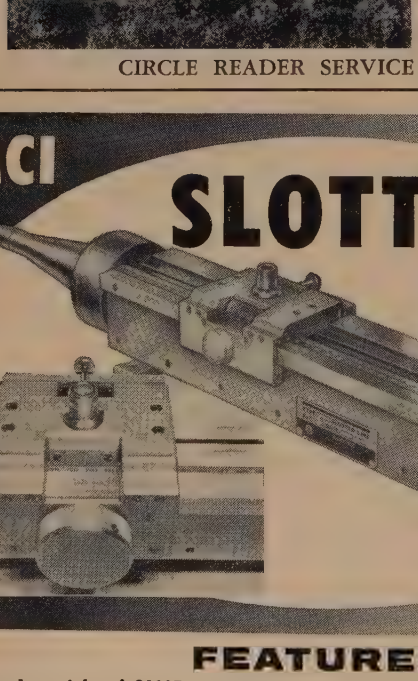
Main Office and Microwave Laboratory Great Neck, N.Y.

In the field of microwave engineering, Wheeler Laboratories occupies a unique position as an industrial laboratory devoted exclusively to consulting and development.

ON LONG ISLAND

WHEELER LABORATORIES, INC.

A SUBSIDIARY OF HAZELTINE CORPORATION



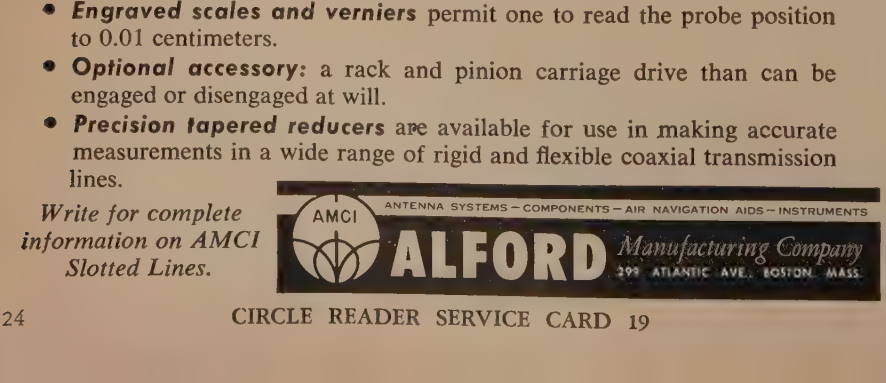
Antenna Laboratory and Test Range Smithtown, N.Y.

As a service to many prominent laboratories and manufacturers, WL designs radar and communication antennas, waveguide components, and microwave assemblies. Your inquiries are invited.

Harold A. Wheeler and Engineering Staff

CIRCLE READER SERVICE CARD 18

AMCI SLOTTED LINES



FEATURES

- ***Rated residual SWR*** — under 1.010; rated error in detected signal — under 1.005.
- ***Several models*** covering various bands from 50 to 4000 mc.
- ***Engraved scales and verniers*** permit one to read the probe position to 0.01 centimeters.
- ***Optional accessory:*** a rack and pinion carriage drive than can be engaged or disengaged at will.
- ***Precision tapered reducers*** are available for use in making accurate measurements in a wide range of rigid and flexible coaxial transmission lines.

Write for complete information on AMCI Slotted Lines.

ANTENNA SYSTEMS — COMPONENTS — AIR NAVIGATION AIDS — INSTRUMENTS

AMCI **ALFORD** *Manufacturing Company*

299 ATLANTIC AVE., BOSTON, MASS.

CIRCLE READER SERVICE CARD 19

TRANSCO ANNOUNCES NEW SALES MANAGER

Nathaniel Davis has been named Gen eral Sales Manager of Transco Produc Inc., West Los Angeles microwave com ponents and system manufacturer.

Mr. Davis has been a Sales Engine with Transco for three years. Prior joining Transco he was Sales Engine for Joe Davidson Associates and in bo Sales and Engineering Departments Westinghouse. His extensive enginee ing and sales experience with an E Degree from the University of Flori make him well qualified for this pos tion.

According to Mr. Davis, emphasis du ing the coming year will be placed o R.F. Transmission Systems utilizing th company design, development and tes ing capabilities.

Transco manufactures a broad line o microwave components which include antennas and coaxial switches; facilitie are being expanded with a new buildin nearing completion.

Transco is located at 12210 Nebrask Ave., Los Angeles 25, California.

• • •

FIRST AN/APX-44 TRANSPONDERS SHIPPED TO SIGNAL CORPS

The Wilcox Electric Company of Kan sas City has announced the initial shi ments on schedule of an $8,000,000 orde for aircraft radar transponders, AN/APX 44, under a major production contra with the U.S. Army Signal Corps, a cording to James E. Gardner, Wilco Executive Vice-President.

The present production contract wa preceded by a development contract th resulted in the AN/APX-44, which en ables a ground-based radar observer t check the identity and position of ai craft within radar range under a weather and traffic conditions. The ne Signal Corps device was developed fro the Wilcox Model 714 ATC Tran ponder, a unit of the Wilcox CANA system, widely used by commercial, bu iness and private aircraft throughout th world.

Over 12,000 precision microwave components, in frequencies from 400Mc to 70 Kmc, are now available to you! MDL has all the junctions, mixers, hybrids, filters, circulators, bends, duplexers, joints and thousands of other adapters, terminations and additional microwave system components, you might ever need.

Because MDL is the leading supplier of precision microwave components, they meet your requirements — quickly, with electrically-tested and proven components. MDL assembles their components into sub-systems to your exact requirements, and MDL component-assemblies are superior, because they are designed to work together. MDL maintains extensive test facilities to insure that your MDL components, assemblies or systems fully meet your specifications, thus relieving you of further test responsibilities.

Start with MDL components — assure yourself of system performance from the start! All components are designed, engineered and manufactured to rigid specifications — the kind of quality control only a component specialist can give. Extensive inventory and production-run manufacturing assure quick delivery and economical pricing. New components are continually being developed and added to MDL's growing inventory.

When you design your microwave systems — design reliability and superior performance right into it from the start — select MDL components and be sure!

Send for complete literature.

MDL

Microwave Development Laboratories, Incorporated

92 Broad Street, Babson Park 57, Wellesley, Massachusetts. Tel: CE 5-6252

CIRCLE READER SERVICE CARD 20

New from Japan . . .

Important advance in short-haul, multi-channel communications

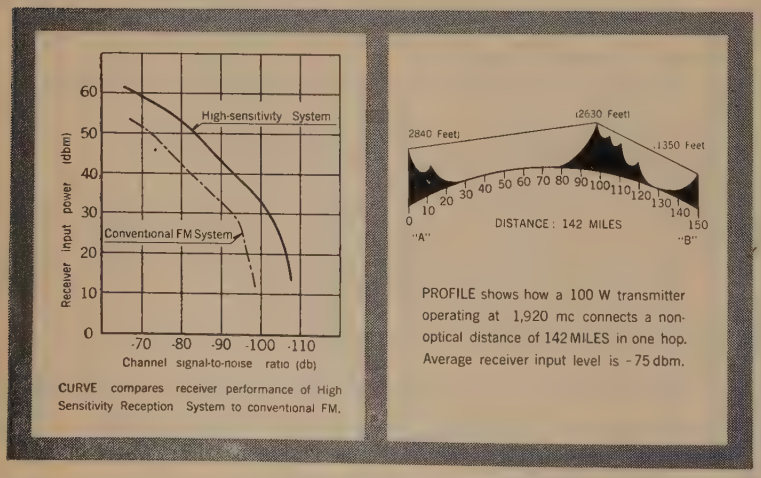
Microwave 60-channel voice transmission over a non-optical path up to 300 MILES is now possible without repeater stations.

NEC's High Sensitivity Reception System, by extending threshold level and improving S/N ratio 10 to 13 db, makes this hop with only 1/20 of the power output required for conventional systems.

A 100 W transmitter in the 1,800-mc band, for example, has a scatter path of 100—150 MILES. A conventional FM system requires 2 KW output and at least one repeater station to connect the same distance over a non-optical path.

By eliminating high-power amplifiers and repeater stations, the High Sensitivity Reception System results in considerable reduction in initial investment. Savings in maintenance and power consumption are estimated at 40% or more.

Extensive propagation tests have been made, and NEC is now prepared to supply commercial users and government agencies anywhere in the world. Please write for detailed information.



CURVE compares receiver performance of High Sensitivity Reception System to conventional FM.

PROFILE shows how a 100 W transmitter operating at 1,920 mc connects a non-optical distance of 142 MILES in one hop. Average receiver input level is -75 dbm.

NEC *Nippon Electric Company Ltd.*

Tokyo, Japan

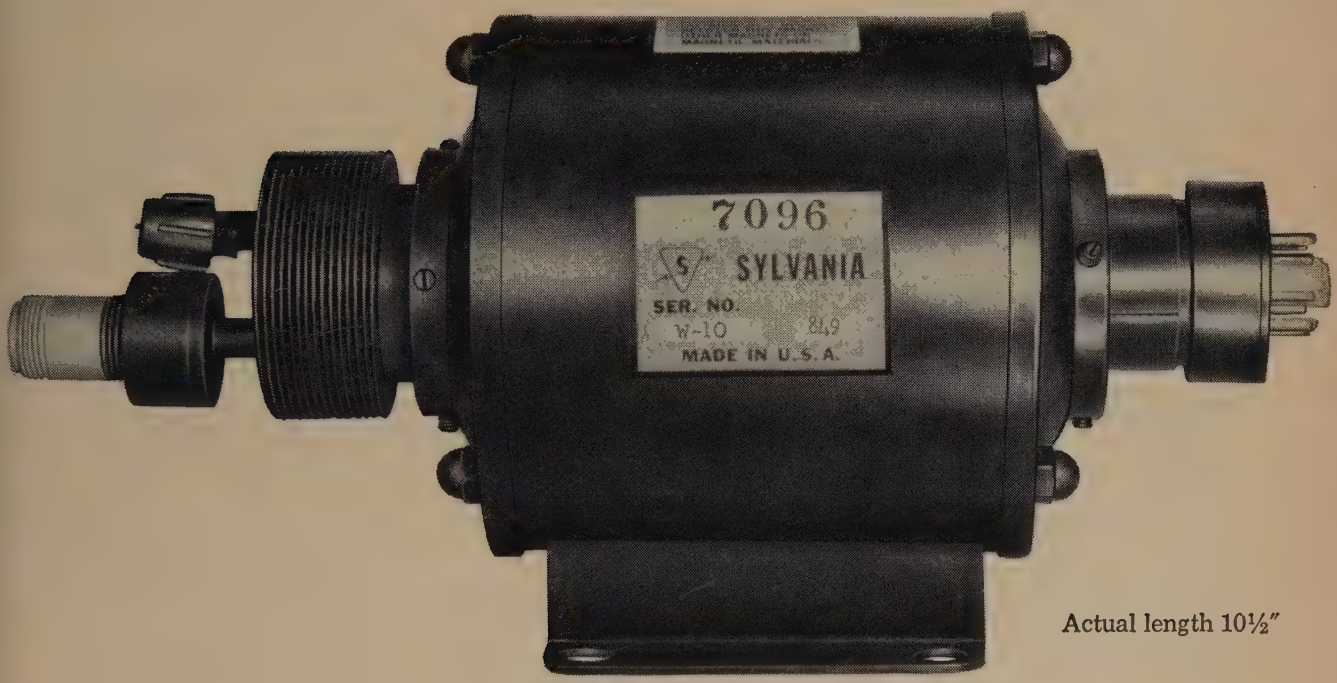
Electronics / Communications Systems

CIRCLE READER SERVICE CARD 21

Microwave Component News from SYLVANIA

NOW IN PRODUCTION:

Widest Range of Backward-Wave Oscillators With Frequencies to 75 kmc



Actual length 10½"

	PM-1779	PM-1757	PM-6902	BW-623	6496	7096	6699
Frequency range, kmc	63-75	27-41	18-27	4-8	2-4	2-4	1-2
Power output, mw	3	5	10	15-135	20-700	100	20-700

Sylvania now offers the widest range of production backward-wave oscillators, featuring 3 rugged types at K-band and above.

Greatly simplified power supply design is made possible through use of the PM-1757 and PM-6902 since their design permits grounding of either cathode or helix. These two BWO's have the following advantages:

Grounded cathode
Rugged metal-ceramic construction
Permanent magnet focusing
Suitable for airborne applications
Rated for CW or pulse applications

For other requirements, Sylvania has classified tubes available at frequencies other than those shown.

SYLVANIA GENERAL SYSTEM

Subsidiary of
GENERAL TELEPHONE & ELECTRONICS

Sylvania Electric Products Inc.,
Special Tube Operations
500 Evelyn Ave., Mountain View, Calif.

CIRCLE READER SERVICE CARD 22

This man is using the industry's most advanced swept microwave oscillator

now available from

ALFRED ELECTRONICS

No other sweeping oscillators offer as many solid advantages as Alfred Electronics' new series 620 models, built by the industry's leading manufacturer of high quality, broadband microwave instruments. Note these features:

★ **Six models, covering 1 to 18 kmc.** Broadest frequency range available. Electronic sweep of RF output, or extremely stable CW operation.

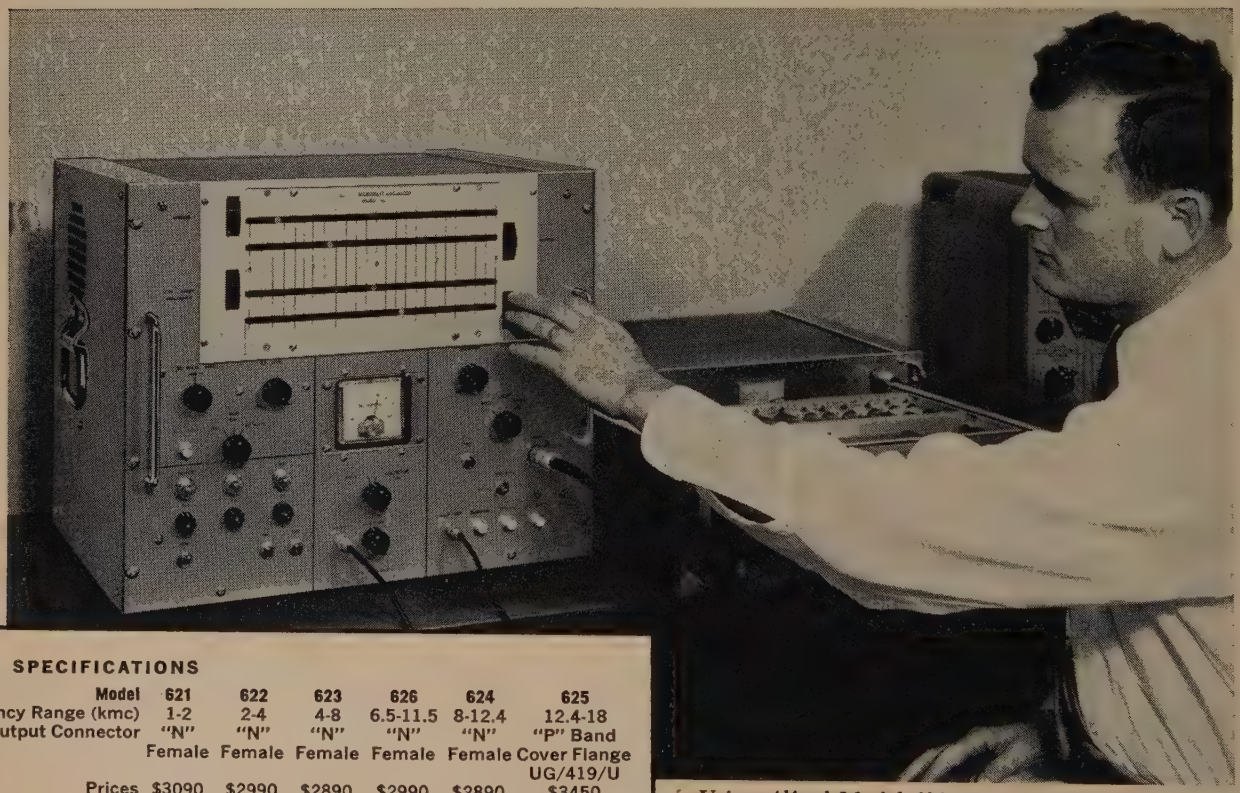
★ **Linear frequency sweep coverage** over all or part of each band for rapid evaluation of reflection coefficient, gain, attenuation and other network transfer characteristics.

★ **Two adjustable frequency markers** for convenient calibration of oscilloscopes or recorders. Markers save valuable test time by indicating either band limits or intermediate frequency values. An exclusive Alfred feature on all models.

★ **0.5 microseconds rise and fall** response to AM—equivalent to a 2 megacycle band pass. Another exclusive Alfred feature.

★ **Quick Look readout.** See frequency range, markers and sweep time at a glance. No cumbersome calculating.

★ **Fast sweep** for flicker-free oscilloscope presentation; slow sweep for mechanical recorder operation.



Using Alfred Model 623 Microwave Oscillator (left) to test small signal and saturation gain of Model 503 Traveling Wave Tube Amplifier. Microwave Leveler, Alfred Model 704, holds power output from oscillator constant within ±1 db.

BRIEF SPECIFICATIONS

Model	621	622	623	626	624	625
Frequency Range (kmc)	1-2	2-4	4-8	6.5-11.5	8-12.4	12.4-18
RF Output Connector	"N" Female	"N" Female	"N" Female	"N" Female	"N" Female	"P" Band Cover Flange UG/419/U
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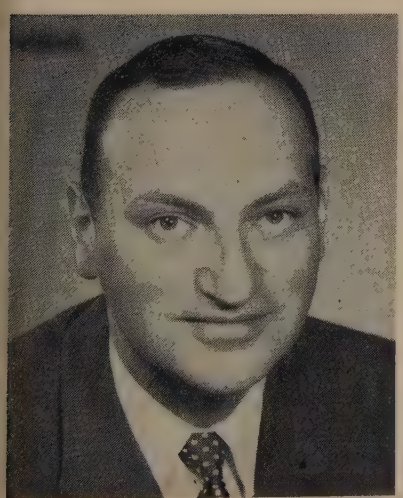

ERVIN NALOS was born in Prague, Czechoslovakia, did his undergraduate work at University of British Columbia and received his Ph.D. at Stanford in Electrical Engineering. Subsequently, he worked as a Research Associate at the Stanford Microwave Laboratory. Together with Dr. Ginzton he published a manual on Microwave Measurements, and in cooperation with Prof. Chodorow developed the first megawatt-type TW tubes. He joined the General Electric Microwave Laboratory at its inception in 1954 and was in charge of a number of advance development programs in the high power TWT area. Currently, he is the Scientific Representative of the General Electric Research Laboratory in Zurich, Switzerland. He has published a number of articles in the microwave field and is active on the IRE Editorial Review Board.

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PRESENT STATE OF ART IN HIGH POWER TRAVELING-WAVE TUBES

ERVIN J. NALOS
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Palo Alto, California

ABSTRACT

The object of this paper is to outline the present state of art in the high power microwave field with special emphasis on linear beam circuits interacting with periodically loaded waveguides.

A number of interaction circuits are discussed, both for "O" and "M" type tubes and areas of advances and future trends are indicated.

I. INTRODUCTION

A. Historical Background

The present effort in the area of high power traveling-wave tubes finds its common root in both klystron development and the original low power helix TWT development. This is in a sense natural, since the achievement of megawatt-type microwave devices was first demonstrated in a klystron [1] whereas broadband amplification was first demonstrated in the low power helix TW tube.[2] Both types of devices use the velocity modulation principle, one in the form of standing waves, the other in the form of traveling-waves. In addition, many similarities in the design of both devices, such as beam formation, extraction of electromagnetic energy, and beam collection, serve to provide a common background of development. The discussion in this paper will deal primarily with linear beam devices with some reference to cross-field devices in order to give a fairly comprehensive picture of the state of art in high power microwave tubes.

The first effort designed to produce megawatts of pulsed microwave power was conducted on the high power pulsed klystron [1] at Stanford. This work conclusively demonstrated that large oxide-coated cathodes could be operated reliably at voltages of several hundred kilovolts, and provided the necessary impetus for further high power research directed toward the achievement of broader bandwidth at high power levels. Although prior to this work, a number of interaction circuits have been suggested by Pierce,[3] Field,[4] and others, their electrical characteristics were considered inferior to the simple helix at all but the highest voltages, where the helix becomes unsuitable. This is primarily due to its good radiating properties when stretched out to be in synchronism with a high velocity beam. With the demonstrated success of the high power pulsed klystron, a much greater interest developed in the utilization of traveling-wave devices in conjunction with high voltage electron beams. Unfortunately, in order to slow the electromagnetic wave down to synchronism with an electron beam, smooth transmission lines such as waveguides cannot be used directly; instead, some form of loading must be used. The periodically loaded waveguide provides a means of doing this.

B. General Discussions of High Power Microwave Tubes

Before proceeding with a detailed analysis of the periodically loaded waveguide, which has proved to be so important in the high power TW tube field, it is appropriate to discuss briefly the present state of art in all types of high power microwave tubes. This is outlined in Table I. Klystrons with their inherently high gain, low power TW tubes with their large bandwidth, and magnetron-like devices with their high efficiency, have all invaded the high power field. It is clear that keen competition between these devices will continue and that no single approach will satisfy all the foreseen needs. As indicated in Table I, hybrid devices exploiting the advantages of two or more different types of interaction may well provide a solution to some of the problems encountered to date.

	KLYSTRON		MAGNETRON		TW TUBE		
A. Present Performance	Synch Tuned	Stagger Tuned	Oscillator	Crossed Field Amplifier	Helix	Helix Derived	Loaded Waveguide
Gain	>60 db	30 db		10 – 15 db	30 db	30 db	30 db
Bandwidth	½ %	5 %		10 %	2:1	30 – 35 %	15 – 20 %
Efficiency	35 %	25 %	50 %	40 %	15 – 25 %	?	25 %
Stability	Good	Good		Poor	Good	Fair	Fair
Average Power	Good	Good		Fair	Low	Fair	Good
B. Improvements							
1. Beam Focusing	Permanent Magnet Space Charge Focusing		Magnetless Magnetron	Centrifugal Focusing (E–Type Devices)	Periodic Focusing: Magnetic + Electrostatic		
2. Beam Formation Hollow Beams High Perveance Multiple Beams	Better r–f Coupling Increased Bandwidth, Lower Voltage Higher Aver. Power		Convergent Injected Beam vs. Emitting Sole for High Aver. Power Resonant Beam Control.		Better r–f Coupling, Higher Gain Increased Bandwidth, Efficiency, Reduced Voltage, Higher Aver. Power		
3. Circuit + Interaction	Higher R/Q Cavities Closer Cavity Spacing Generalized Drift Tube		Novel Circuits for Higher Gain Waveguide Coupled Circuits Forward Wave Interaction		New Circuits for Hollow Beams Tapered or Segmented Circuits for Flat Gain and Better Efficiency Multi–Severed Circuits for High Gain, Selective Mode Loading for Better Stability.		
4. Hybrid Devices	Stagger Tuned Klystron Buncher with TWT Output TWT Buncher with Klystron Output "O" Type Input Circuit with "M" Type Output Circuit Proposed						

Table 1 — High Power microwave tubes (S-Band).

The present effort to extend the state of art in these three fields has proceeded as follows:

1. The simple synchronously tuned multi-cavity klystron, capable of stable gains in excess of 60 db, has been adapted to provide means of detuning the intermediate cavities to give an increased bandwidth at some sacrifice in gain. Gains of 30-40 db have been obtained over a 3-5 per cent bandwidth at megawatt levels by stagger-tuning the initial cavities and broadbanding the output system by loading or the use of multiply-tuned cavities. Efficiencies of about 30 per cent are achievable in these types of tubes.

2. The crossed-field amplifier, with its inherently high efficiency (typically 40-50%) has given megawatts of peak power at the lower microwave frequencies, with CW capabilities in the range of hundreds of watts. Considerable effort is continuing to obtain better understanding of the complex interaction of the magnetron type with traveling-wave fields. A number of new slow-wave circuits for crossed-field devices are also being considered. There are no basic differences in the types of slow-wave circuits designed for linear-beam or crossed-field interaction except for the difference in synchronous voltage for a given power level. Perhaps the most distinguishing features of the crossed-field amplifier to date is its predominant operation on a backward-wave, whereas all broadband "O" type traveling-wave amplifiers interact with a forward-wave.

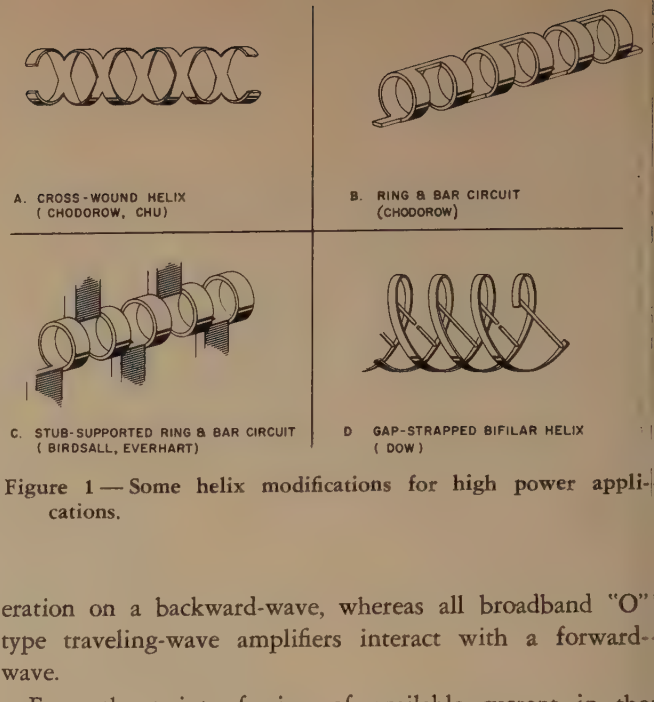

Figure 1 — Some helix modifications for high power applications.

From the point of view of available current in the crossed field device, amplification can be achieved by either the use of an injected beam from outside of the r-f circuit, or by the use of a continuously emitting surface. The beam can be collected, or made re-entrant. It is not clear to date which of these two methods of current generation offer greater promise for higher power applications. Both types of injection have achieved stable gains in the 10-15 db region but the mechanism which limits the gain is not yet clearly understood.

3. The simple helix is still the most frequently employed slow-wave circuit in TW tubes. It has been used in low noise applications, in medium power amplifiers (with a CW capability as high as 10 watts at X-band), and in pulsed applications (as high as several kilowatts at S-band). In addition, it has found application in electronically tunable oscillators and amplifiers. Considerable work has been expended to modify the simple helix into circuits suitable for higher voltage interaction and higher average power capability. Some of these are shown in Figure 1. For example, a four helix circuit developed by Putz [5] has made it possible to develop 100 watts of CW power at X-band over an almost 2:1 frequency range (see Figure 2).

The evolution of the contrawound helix [7] (Figure 1A) and its close relative, the "ring and bar" circuit [6, 7, 8] (Figure 1B) have extended the useful range of operating voltages to the 20-70 kv range as well as allowing the use of larger transverse dimensions at a given frequency. Tens of kilowatts of peak power have been achieved with these circuits. The stub-supported helix (Figure 1C) appears capable of extending the average power range although at some sacrifice in bandwidth. Modified multifilar helices have also been suggested for high power TWT applications.[9] One such modification, thought promising for large bandwidth at high peak powers is the gap-strapped bifilar helix shown in Figure 1D. These devices are illustrative of the advances in the field of helix-derived circuits. It appears, however, that in the 10-30 per cent

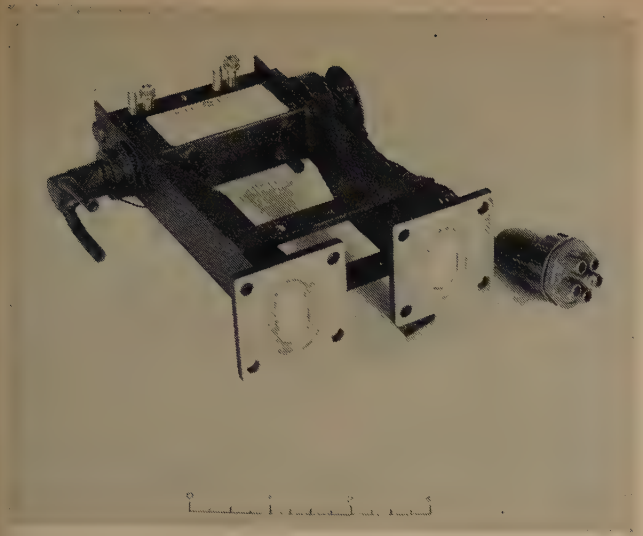

Figure 2—Z-5161 100 watt X-Band 4-Helix traveling-wave tube.

bandwidth region, the periodically loaded waveguide offers the greatest promise in achieving both high peak and average power simultaneously. The main emphasis of this paper lies in this area.

II. PERIODICALLY LOADED WAVEGUIDE CIRCUITS

A. General Considerations

The simple waveguide is basically a high pass filter, propagating energy with a phase velocity greater than light velocity at all frequencies. Any periodic loading of the circuit will result in cumulative reflections from the loading obstacles, which at some ranges of frequencies will cause total reflections, i.e., a stopband. The high pass filter thus becomes a bandpass filter, whose properties depend on the nature of the periodic loading. If the loading obstacles are small, little change from the waveguide characteristic will occur except near the regions of total reflections, curve 2, Figure 3. The new branches of the so-called "Brillouin" diagram (ω-β diagram) are required to fulfill the boundary conditions inside the composite circuit and are referred to as the spatial harmonics. They are mirror images of the fundamental passband and their amplitudes are determined by the detailed nature of the loading obstacles. If the loading is heavy, the waveguide passband is so greatly perturbed that it bears little relation to its original form. In many instances, it is convenient to visualize the slow-wave circuit as a set of resonant cavities coupled together by means of electric or magnetic fields. In the limit of zero coupling (no slots between cavities, or a resonant slot), the passband shrinks to zero, curve 4, Figure 3. With predominantly electric coupling (capacitive) the phase and group velocity in the first quadrant are of equal sign; giving curves 2 and 3, Figure 3; this is referred to as fundamental forward-wave interaction. With predominantly magnetic coupling (positive inductive coupling), the group velocity in the first quadrant is of the opposite sign to the phase velocity (curve 5, Figure 3), and a fundamental backward-wave results. In the last case, for the next quadrant, ($\pi - 2\pi$ phase shift), the group and phase velocities are of the same sign again, giving the so called spatial harmonic forward-wave interaction. The slope of the intersecting dotted line gives the Vp, while the slope of the ω-β curve itself at the operating point gives the Vg. In the forward wave, these are of the same sign. In the backward wave they are of opposite signs. For broadband operation, it is desirable to have the phase velocity nearly constant with frequency, i.e., low dispersion. It is seen in Figure 3, that in general, the fundamental forward-wave circuit is more dispersive than the spatial harmonic circuit, but the impedance is usually higher in the first quadrant since one is interacting with the main component of the r-f field.

A number of slow-wave circuits have evolved around the periodically loaded waveguide, both of the spatial harmonic type and of the fundamental forward-wave type. The first device of this type which employed interaction of a beam with a traveling-wave was the linear accelerator[10] developed by Hansen at Stanford. This circuit is composed of a cylindrical pipe, periodically loaded by capacitive discs, whose phase velocity has been slowed down to the velocity of light (at midband) for purposes of accelerating an electron beam, rather than extracting energy from it, i.e., converting microwave energy into pulsed high voltage d.c. energy. The circuit has the properties of a passband filter whose bandwidth depends on the size of the coupling aperture. For the linear accelerator application, this is made very narrow; to obtain broadband characteristics the detailed nature of the coupling between the periodic obstacles must be examined. As contrasted with the simple helix, the periodically loaded waveguide offers some attractive features: it is rugged physically, and for a given frequency it is larger in size. Both these features tend to enhance its ultimate average power capabilities. On the other hand, due to the dispersive nature of the slow-wave circuit, the bandwidth tends to be limited. Although considerable attention has been given to various filter type circuits by Pierce,[3] they were never seriously

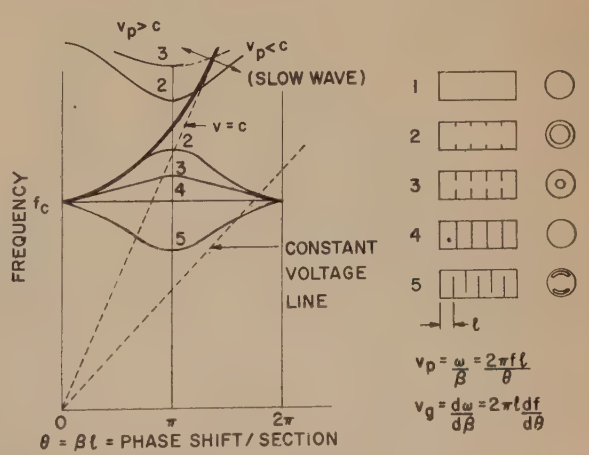

Figure 3 — Brillouin Diagram (ω-β Diagram) for periodically loaded circuits.

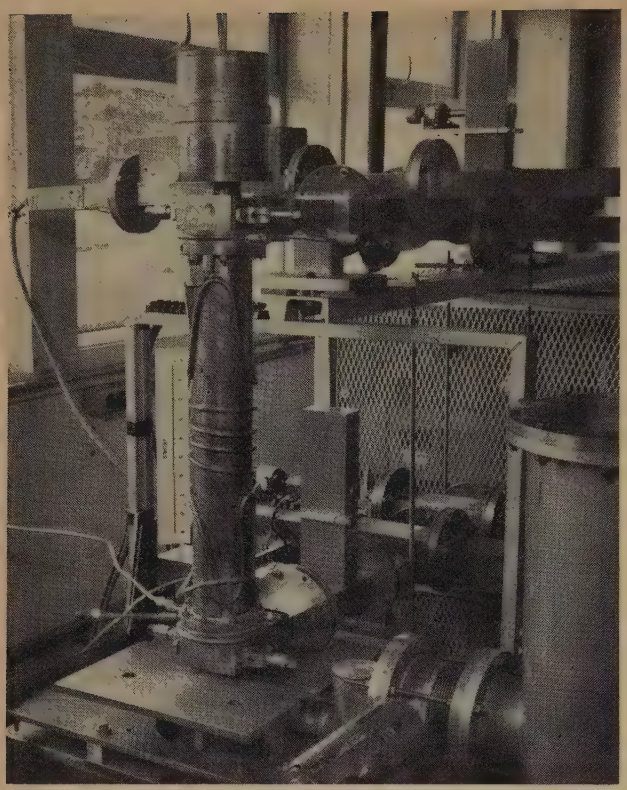

Figure 4 — First S-Band Megawatt-type disc loaded TW tube (Stanford).

considered for TW amplification until interest arose in higher peak and average powers than could be achieved with helix-type circuits. The first of these devices was a spatial harmonic type TW tube described by Chodorow and Nalos,[11] which gave in excess of 300 kw of pulsed power at S-band over a 10 per cent bandwidth (Figure 4). After the successful demonstration of the feasibility of this type of device, a great deal of interest was stimulated in a number of industrial and research institutions, leading to a wider exploitation of the periodically loaded waveguide as a slow-wave circuit. Both forward-wave circuits and spatial harmonic circuits were evolved and tried with the object of improving impedance and bandwidth. A comprehensive analysis of periodically loaded waveguide circuits for high voltage applications has been made by Craig,[12] pointing out the relative advantages of several classes of circuits. The selection of the circuit depends to a great degree on the desired voltage of operation and the desired bandwidth. Spatial harmonic circuits are usually characterized by relatively long field-free drift spaces designed to hide the beam during periods at which it would be decelerated by the field, whereas the fundamental forward-wave circuits need not employ such drift tubes because the main component of the field is in synchronism with the beam. The energy stored per unit length, W, for a given amount of useful r-f field E, is given by

$$\frac{E^2}{W} = \left(\frac{E^2}{2\beta^2 P}\right) 2v_g\beta^2 \sim Kv_g$$

It is thus proportional to the r-f impedance K and the group velocity, v_g. For a typical set of parameters suitable for fundamental and spatial harmonic interaction, using a solid beam, a comparison of the energy storage factors at

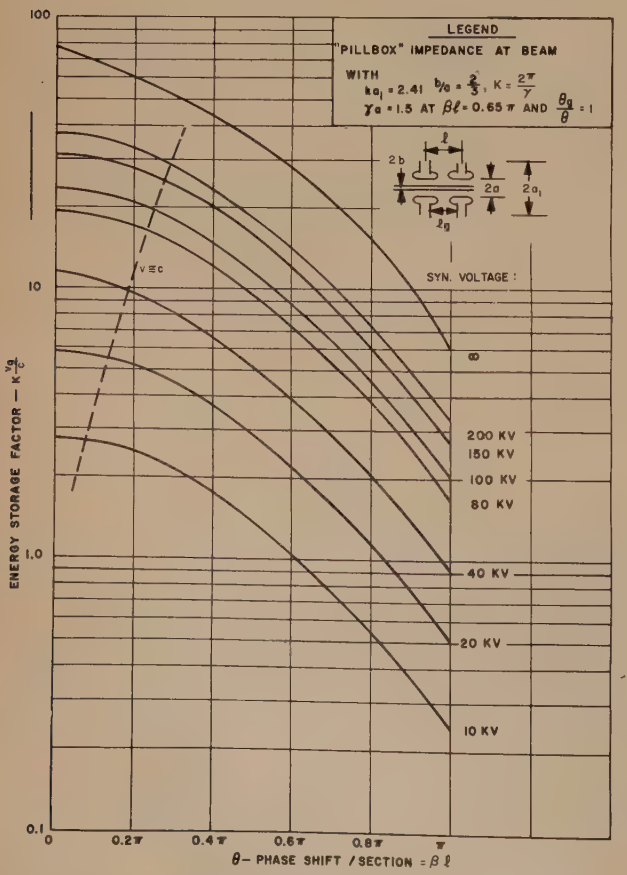

Figure 5a — Calculated energy storage factors: fundamental interaction.

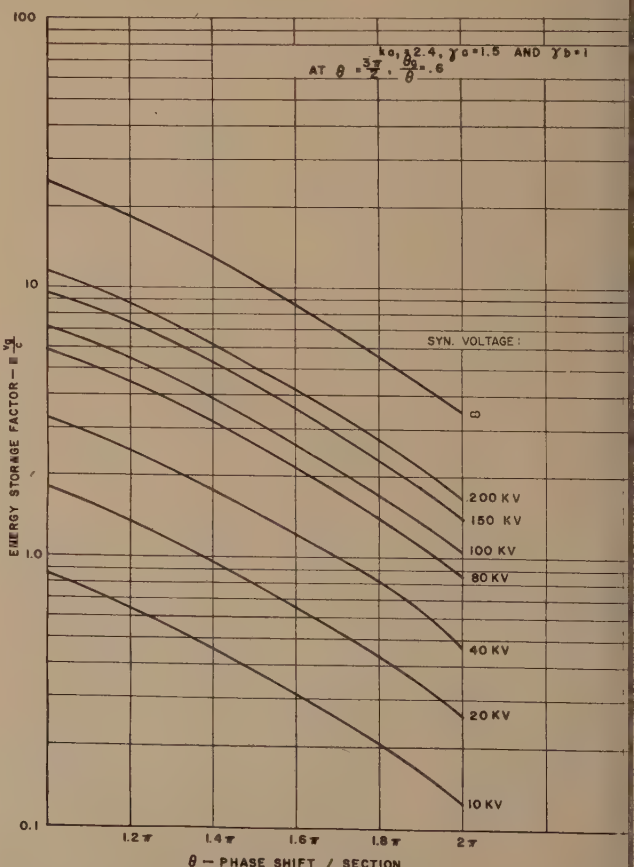

Figure 5b — Calculated energy storage factor: spatial harmonic interaction.

various voltages is given in Figures 5A and 5B. It is seen that as far as impedance is concerned, a fundamental interaction is to be preferred.

In the following sections some applications of loaded-waveguide circuits will be described as used in present high power TW tubes, crossed-field devices and devices used for generation of high frequency waves. It will be seen that a wide range of both forward-wave and backward-wave circuits has been employed, depending not only on bandwidth and impedance considerations but also on adaptability to manufacture and compact focusing.

B. Circuits for High Power "O" Type TW Tubes

Both fundamental and spatial harmonic interaction has been employed for this application. Some circuits have employed a perturbation of the basic waveguide TM_{01} mode, whereas others have used a coaxial mode perturbed by the waveguide wall. It is possible to regard the field configurations of the slow-wave circuits as derived from several different basic transmission-line modes; the view presented here is one of convenience and usefulness to the author but is by no means the only one.

1. Fundamental Forward-Wave Circuits

Two types of forward-wave circuits will be discussed; one where capacitive coupling is obtained by means of an aperture near the axis of the circuit where strong electric fields exist, and the other, where negative inductive coupling is obtained by means of special slots in the region of the magnetic field.

a. Capacitively Coupled Circuits

Some typical fundamental forward-wave circuits are shown in Figure 6. The size of the capacitive aperture determines the bandwidth and the limitation of the circuit, Figure 6A, is given by the maximum size aperture allowed to obtain good r-f coupling to the beam. Obviously, if a hollow beam of adequate power capability can be employed, this limitation is removed because good r-f coupling can be maintained regardless of aperture size. Some methods to overcome this limitation are suggested in Figures 6B and 6C, where the coupling to the beam is achieved by grid-like vanes, or offset coupling holes.

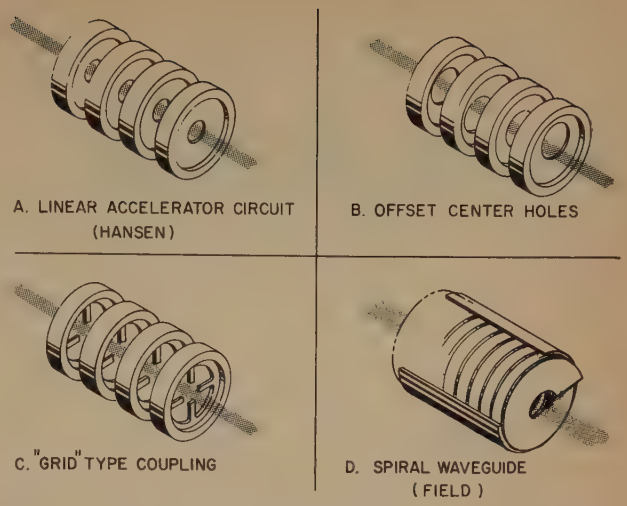

Figure 6 — Some fundamental forward-wave circuits (capacitive coupling).

b. Reversed-Loop Coupled Circuits

By means of a novel type of coupling, suggested by Chodorow and Craig,[13] it is possible to increase the bandwidth of the circuit with a fixed size center aperture using reversed loops, illustrated in Figure 7A. This type of coupling provides a microwave equivalent of a negative mutual inductance (i.e., a reactance of the same sign as that due to capacitive coupling) and has been successfully evolved at Stanford into slow-wave circuits of the "cloverleaf" type[12] and the "centipede" type[13] shown in Figures 7B and 7C.

A TW tube of the cloverleaf type which has given 2 megawatts of peak power at S-band over a 10 per cent frequency band is shown in Figure 8. Tubes of a similar type have been built at SERL (England), General Electric Microwave Laboratory, and Varian Associates.

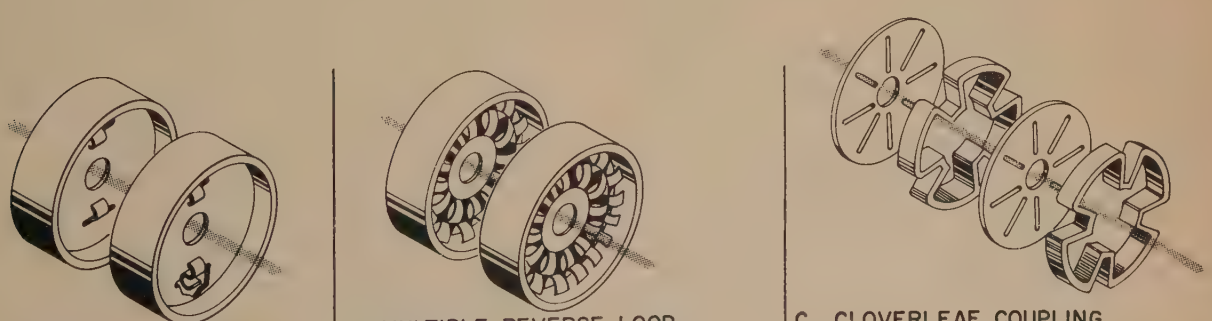

Figure 7 — Circuits with negative inductive coupling (Craig, Chodorow).

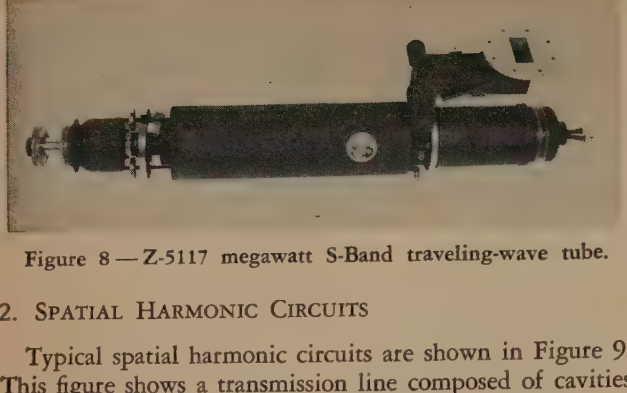

Figure 8 — Z-5117 megawatt S-Band traveling-wave tube.

2. Spatial Harmonic Circuits

Typical spatial harmonic circuits are shown in Figure 9. This figure shows a transmission line composed of cavities coupled by mutual (positive) inductance, resulting in a fundamental backward-wave. A single-slot spatial harmonic circuit is shown in Figure 9A and a double-slot circuit is shown in Figure 9B. As the coupling is increased, one obtains in the limit a drift tube supported by wires (or a single wire) as shown in Figure 9C and 9D. One such circuit has been evolved and tested at the General Electric Research Laboratory by M. Boyd.[14] He used an electron pencil* with an external circuit to demonstrate a 40 kw pulsed capability at 500 mc with an efficiency of 25 per cent. The passband shape may be altered by relative rotation of the slots from section to section. It is of interest to note that the passband of the circuit in Figure 9A and 9B is in the vicinity of the TM_{01} cutoff for the circular pipe, whereas in Figure 9C, the passband is centered around the resonance of the wire $\left(\frac{\lambda}{2}\right)$ and is relatively independent of the shape of the enclosing circuit. The above argument applies when the coupling slot is purely inductive; if the slot is made resonant near the operating frequency range, a new passband will occur which may interfere with the desired mode of operation. If the slot is above resonance at the frequency of interest, it will become capacitive and cause higher order fundamental forward-wave propagation to exist. The utilization of this mode depends on the extent to which the lower frequency modes are successfully repressed or not interacting with the beam. A slow-wave circuit using long circumferential slots for high power application has been suggested by Kino and Allen.[15]

*An electron gun and focusing system surrounded by a dielectric envelope around which various interacting circuits may be placed.

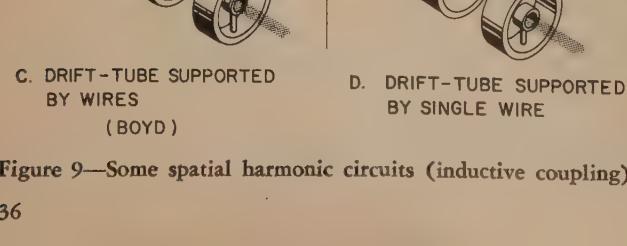

Figure 9—Some spatial harmonic circuits (inductive coupling).

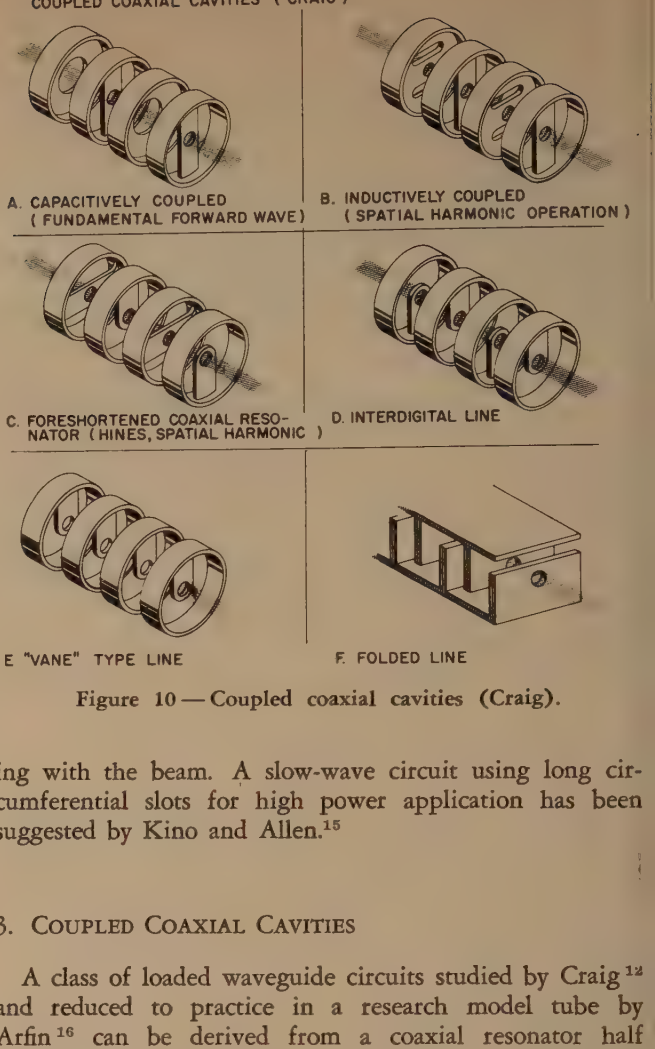
COUPLED COAXIAL CAVITIES (CRAIG)
A. CAPACITIVELY COUPLED (FUNDAMENTAL FORWARD WAVE)
B. INDUCTIVELY COUPLED (SPATIAL HARMONIC OPERATION)
C. FORESHORTENED COAXIAL RESONATOR (HINES, SPATIAL HARMONIC)
D. INTERDIGITAL LINE
E "VANE" TYPE LINE
F. FOLDED LINE

Figure 10 — Coupled coaxial cavities (Craig).

3. Coupled Coaxial Cavities

A class of loaded waveguide circuits studied by Craig[12] and reduced to practice in a research model tube by Arfin[16] can be derived from a coaxial resonator half wavelength long. Such resonators, either in a rectangular or cylindrical geometry, can be coupled together by means of capacitive or inductive apertures, giving either a fundamental forward-wave circuit, Figure 10A, or backward-wave circuit, Figure 10B. It is possible to obtain similar behavior by simply foreshortening the inner conductor of each coaxial section into a finger, as shown in Figure 10C. This circuit modification, suggested by Hines, has been successfully used in a number of CW applications at voltages in the 5-15 kv range. The research model built by Arfin has given a kilowatt of pulsed power at X-band over a 20 per cent bandwidth and a developed tube of a similar type, designed at the General Electric Microwave Laboratory, by Mr. R. Phillips, is shown in Figure 11.

By removing the coupling aperture entirely, one arrives at the simple interdigital circuit, Figure 10D, or the "vane" type line, Figure 10E, depending on which side of the coaxial bar is foreshortened. The interdigital line was originally investigated by Fletcher[17] and together with its close relative, the folded waveguide, Figure 10F, has found extensive use in low and medium power oscillators and amplifiers. Voltage-tunable backward-wave oscillators giving 100 watts CW at S-band with 12 per cent efficiency have been built using the folded line.[18] A slightly modified vane-type line which also exhibits a backward-wave was first used by Millman[19] to demonstrate spatial harmonic interaction in the 6 mm region and it was on this tube that Kompfner first observed backward-wave interaction.

Figure 11 — Z-5184 High Power Ku-Band traveling-wave tube.

c. Periodically Loaded Waveguides for Millimeter Wave Applications

The slow-wave circuits described in the previous section are indicative of the effort in the area of broadband amplification at high peak and average powers. Obviously, with the increasing interest in this field, we can look to further innovations and improvements of performance. The impact of this work is also being felt in the generation and amplification of microwave energy in the millimeter wavelengths, where comparable power densities dictate the use of rugged structures. Waveguides periodically loaded by slots of the type developed by Karp,[20] (Figure 12A) have been successfully used as backward-wave oscillators in the 100-200 kmc region. A similar circuit, where the loading slots occur in the waveguide ridge rather than in the waveguide wall has been used in Millman[19] (Figure 12B) as a low power spatial harmonic amplifier at 6 mm wavelength.

Both these circuits employ fundamental backward-wave interaction and the geometry has been selected so that the circuits can be fabricated accurately with small dimensions. The Karp circuit, for example, is made by winding a helical wire on to a cylindrical bar into which two slots are machined to simulate the ridges of the waveguide. A number of proposals for forward-wave circuits have also been made for millimeter wave generation. One such class is the ladder circuit. In its simplest form, the slotted plane ladder, (Figure 12C) propagates a forward-wave with nearly the velocity of light at lower frequencies; near the high frequency cut-off where the slots are resonant, the velocity is slowed down for suitable interaction with an electron beam. The principle can be extended to higher power by the use of multiple-ladder circuits in conjunction with a number of electron beams.[21] This class of circuits appears to have good impedance at high velocities and can presumably be extended into a three dimensional array by stacking multiple ladders side by side.

The basic plane ladder circuit can be modified by the addition of side walls to introduce a low frequency cutoff which depends on the side wall geometry.[21] If the slot length extends right to the wall, the passband shrinks to zero, since the electric and magnetic coupling for this special case cancel. This is the "Easitron" circuit of Walker shown in Figure 12E. If the sidewall is removed from the slot edge (Figure 12F), one obtains a finite pass band. Either capacitive or inductive coupling can be made to dominate by adjusting the side wall geometry. Circuits (i) and (iii) in Figure 12F are forward-wave circuits of the "open" type, whereas circuit (ii) is a backward-wave circuit of the "closed" type. Proposals have been made to evaluate such circuits in actual tubes, but to date only preliminary results have been obtained.

d. Circuits for Crossed Field Interaction

The basic criteria for slow-wave circuits in crossed-field devices are no different from those in "O" type devices; however, since the beam is usually dissipated along the circuit, a higher average power capability is required for the "M" type circuit. Also, for a given operating voltage, the synchronous velocity in the crossed-field device is much lower than in the "O" type device. This means that the periodic spacing and size of circuit is smaller physically. The over-all compactness thus results in an average power capability which at a given frequency is lower than the "O" type device. This is offset by the efficiency which can be achieved, and the choice between an "O" and "M" device is usually not clear cut, depending on the specific application. The magnetron amplifier was first built in France[22] using an injected beam, and a related device, the Amplitron,[23] which uses a continuously emitting cathode, was obtained by Brown by severing the r-f structure of a conventional magnetron oscillator. The geometry may be either cylindrical or linear. Some of the slow-wave circuits used in these devices are shown in Figure 13.

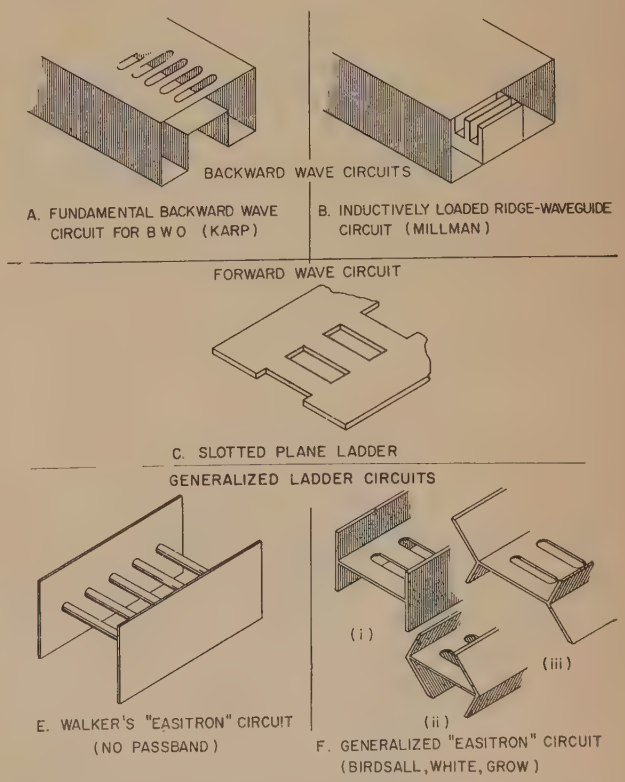
BACKWARD WAVE CIRCUITS
A. FUNDAMENTAL BACKWARD WAVE CIRCUIT FOR B W O (KARP)
B. INDUCTIVELY LOADED RIDGE-WAVEGUIDE CIRCUIT (MILLMAN)
FORWARD WAVE CIRCUIT
C. SLOTTED PLANE LADDER
GENERALIZED LADDER CIRCUITS
(i)
(iii)
(ii)
E. WALKER'S "EASITRON" CIRCUIT (NO PASSBAND)
F. GENERALIZED "EASITRON" CIRCUIT (BIRDSALL, WHITE, GROW)

Figure 12 — Loaded waveguide circuits for millimeter waves.

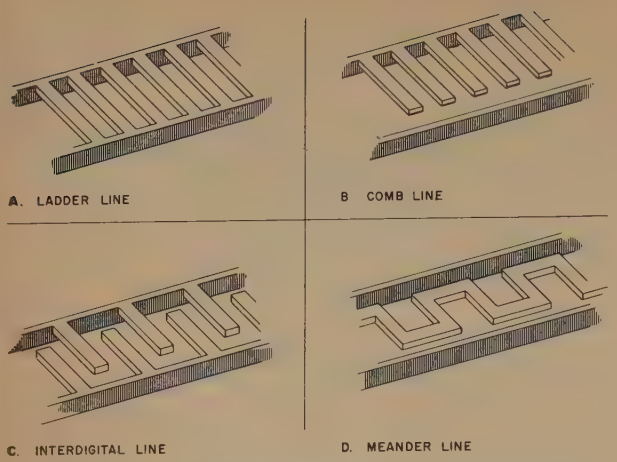

Figure 13 — Some circuits for crossed-field interaction.

These basic circuits are similar to those already discussed and their analysis for crossed-field interaction has been given by Leblond and Mourier.[24] Again, these circuits, such as the ladder line for example, can be modified by introduction of a loading ridge below the circuit. Depending on the location of the ridge, a Karp-type circuit giving either forward-wave or backward-wave interaction can be obtained. Interestingly enough, such circuits have also been used for TW Maser applications.

A promising innovation which stemmed from the work at Bell Telephone Labs on the coaxially tuned magnetron is the waveguide-coupled circuit, one type of which has been investigated by Feinstein and Collier.[25] The energy is coupled from a transmission line adjacent to but separate from the slow-wave circuit with which the beam interacts. The coupling is accomplished by means of periodic apertures along the circuit. Greater flexibility in design is obtained, with the possibility of increased impedance and greater ease of coupling. A schematic diagram is given in Figure 14. For the geometry shown, if every alternate slot is coupled, one obtains a backward-wave circuit, which has been tested with peak powers of a fraction of megawatt. Greater bandwidth can be expected with forward-wave interaction, obtained by coupling every resonator. It is clear that such circuits can be used equally well for "O" type interaction.

END PART I

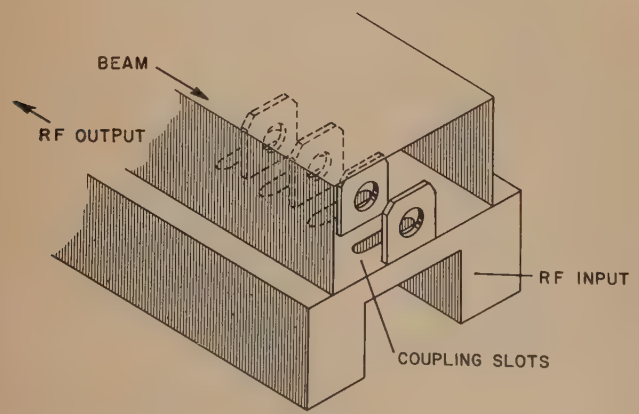

Figure 14 — Waveguide coupled circuits (Feinstein, Collier).

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A BROADBAND ANTENNA SHIELD AND TEST COUPLER

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Introduction

In many applications it is desirable and, often, necessary to test a complete transmitting system radiating through the antenna. One notable example is in pre-flight line testing of R.F. systems mounted in operational aircraft. If the antenna is allowed to radiate into free space, a rather serious personnel hazard will exist. There is the further problem of R.F. interference with neighboring receivers and the leakage of frequency information (as is carrier operation). A need exists, therefore, for a portable antenna capping device which can absorb R.F. power.

Since there is usually a requirement, in pre-flight testing, for a sampling test on the radiated power, it is important to provide means for coupling to a known portion of the transmitter output. The obvious technique of providing a directional coupler in the transmission line between the transmitter and the antenna, is not feasible in many cases due to space and weight limitations. Since R.F. systems are permanently mounted in place in the aircraft, the temporary installation of a coupling device is not practical, and the only accessible terminal is the radiating aperture of the antenna. There are an unlimited number of antenna configurations in present use and it appears impossible, at this time, to develop a single coupling termination for universal application.

The generic group of broadband antennas, characterized by a unidirectional Cosine radiation pattern with a specified degree of elliptical polarization, has found wide application in service use. The target specifications were set, therefore, to enable wide application of the first coupler with the general antenna form.

The desired specifications are listed below:

1. The VSWR of a given antenna, when terminated by the shield, shall not increase above a value set by the following formula:
   Max. VSWR $\leqslant$ 1.15 X Max. VSWR (free space).
2. The overall frequency range shall extend from approximately 1.0 Kmc/s — 10.0 Kmc/s in a minimum of six discreet frequency bands. Each frequency bandwidth shall be approximately 50%.
3. In each frequency band a sample of the R.F. Power shall be coupled out; the nominal coupling shall be 40 db. Effective coupling variation shall be minimized about this value. The power shall be measured through a 25 foot length of RG-9B/U coaxial cable. (The cable is provided merely for convenience when the antenna is rather remotely located.)
4. The unit shall be as small and as light in weight as possible. Also, the unit must be able to "weather" indefinitely, — that is, constant exposure to environmental conditions without deterioration.

Design Procedure:

To insure low VSWR performance and minimum physical size, the main body of the unit was made circular in basic cross-section, with a nominal diameter large enough to support the principal mode at 1 Kmc when operating as a lossy cylindrical waveguide. The main body was, therefore, fabricated from a cylindrical can approximately nine inches in diameter, twelve inches in length, and fitted with a thin lining of specially prepared lossy material. The back end of the main shell was fitted with a lossy truncated cone serving as a low reflection termination.

At the lower frequencies, the unit operates basically as a circular waveguide. At the higher frequencies, however, it was anticipated that a severe discontinuity would exist between the smaller antenna apertures and the cylinder, if the two were joined abruptly. The junction would not necessarily have an adverse affect on the antenna VSWR since the cylinder would behave somewhat as an anechoic chamber. The discontinuity would have its greatest affect, however, on the coupling variation within any given band. A set of lossless tapered transitions, six inches in length, were chosen to adapt the nine inch cylinder to the approximate antenna aperture for the specified higher frequency bands.

To achieve proper coupling, a number of factors had to be considered. The problem is somewhat complicated by the fact that the transmitting antenna is elliptically polarized and that the angular orientation of the polarization ellipse might continually shift with frequency within a given band. In order to facilitate rapid field measurements, it also had to be assumed that the unit would be mounted against a particular antenna, with random axial orientation. The implication here is that the coupling factor shoud be constant with the relative axial rotation of the unit with respect to the antenna.

If a pair of identical probes or coupling elements are located orthogonal to each other, and at the same cross-sectional plane, then the sum of the powers detected by the probes would be proportional to the total power contained in the propagated field. This principle holds for circularly, elliptically, or linearly polarized fields.

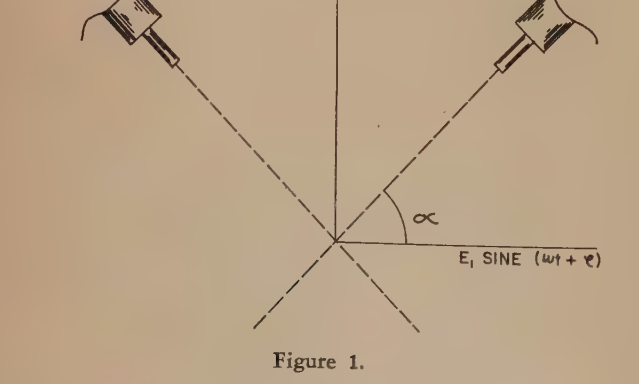

Figure 1.

Furthermore, the summation is independent of relative axial orientation of field and probes. This may be shown as follows:

If we assume the perfectly general case of elliptical polarization, the field may be represented by two field vectors as shown in Figure 1. Note that the orthogonal probes are oriented to these fields with an arbitrary angle, α. The probes will then couple the following fields:

$$I \propto E_1 \text{ sine } (\omega t + \phi) \cos \alpha + E_2 \text{ sine } \omega t \text{ sine } \alpha$$
$$II \propto -E_1 \text{ sine } (\omega t + \phi) \text{ sine } \alpha + E_2 \text{ sine } \omega t \cos \alpha$$

To determine power:

$$P \propto \frac{1}{\pi} \int_0^{\pi} I^2 \, d(\omega t) + \frac{1}{\pi} \int_0^{\pi} II^2 \, d(\omega t)$$

$$P \propto \frac{1}{\pi} \int_0^{\pi} (I^2 + II^2) \, d(\omega t)$$

$$P \propto \frac{1}{\pi} \int_0^{\pi} [E_1^2 \text{ sine}^2 \omega t + E_2^2 \text{ sine } (\omega t + \phi)] [\text{sine}^2 \alpha + \cos^2 \alpha] \, d(\omega t)$$

but $\text{sine}^2 \alpha + \cos^2 \alpha = 1$

$$\text{then } P \propto \frac{1}{\pi} \int_0^{\pi} [E_1^2 \text{ sine}^2 \omega t + E_2^2 \text{ sine}^2 (\omega t + \phi)] \, d(\omega t)$$

$$P \propto \frac{E_1^2}{2} + \frac{E_2^2}{2}$$

In other words, the total power coupled from the probes is proportional to the sum of the squares of the r.m.s. values, *and independent of the angle* α.

If the coupled power from each probe is measured, and the sum of the two outputs added, the result will be an accurate measure of the power contained in the propagated field.

For simplicity, a thin stub working against the lossy lining as a ground plane was chosen for the coupling element. In the lower frequency region the stub is a highly capacitive element and coupling is achieved in much the same manner as in a standard rectangular waveguide. For the higher frequencies, however, the element has considerable radiation resistance and the cylinder, being many wavelengths in outline, behaves as an anechoic chamber. Coupling then is accomplished between two antennas whose radiation patterns intersect, but which are located in the near field region. This assumes that the transmitting antenna and its lossless taper are considered to be a tapered horn with a nine inch circular aperture. (It may be shown that the above concepts are approximately true for, if the lossy cylinder is removed, and a coupling stub placed at the same location relative to the transmitting antenna, a similar coupling factor will be obtained.)

The exact analysis of the coupling between two antennas situated in the near field is formidable and practically unnecessary since the final coupling design was readily arrived at empirically.

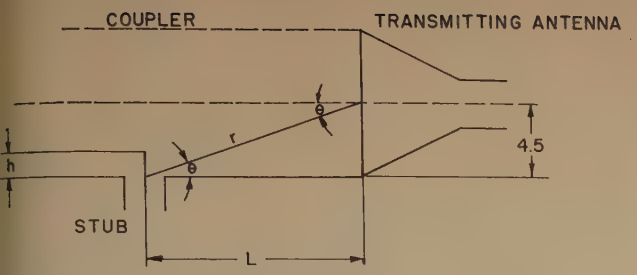

Figure 2 — Geometric relation of antenna and coupling element.

If the assumption was made that the antennas were operating in the far field, and that the lossy lining produced no reflection, a rough estimate of the coupling could be made using the free-space transmission formula presented by H. T. Friis.[1]

This equation may be written as:

$$(1)\quad \frac{W_r}{W_t} = \frac{A_{er}\, A_{et}}{\lambda^2\, r^2}$$

where the ratio $\frac{W_r}{W_t}$ represents the coupling between antennas.

A_{et} and A_{er} are the effective apertures of the transmitting and receiving antennas respectively

λ is the free space wavelength

r is the distance between antennas.

The effective apertures for the antennas involved are known so that the coupling is easily calculated if both antennas are lined up along the same radiating axis.

The geometric relation of the antennas in the coupler is shown in Figure 2 where the stub is located a linear distance, L, from the front face of the unit. The coupling formula is here modified to account for the fact that both antennas are radiating off beam peaks by the angle θ. It is assumed that the angle θ is formed by drawing a ray line between antenna centers. Parameters $_L$ and $_h$ can then be calculated for the proper coupling. Stub height $_h$ also influences coupling by altering reflective loss on the stub.

[1] "A Note on a Simple Transmission Line Formula," Proceedings of I.R.E. — 34, 254-256, May 1946.

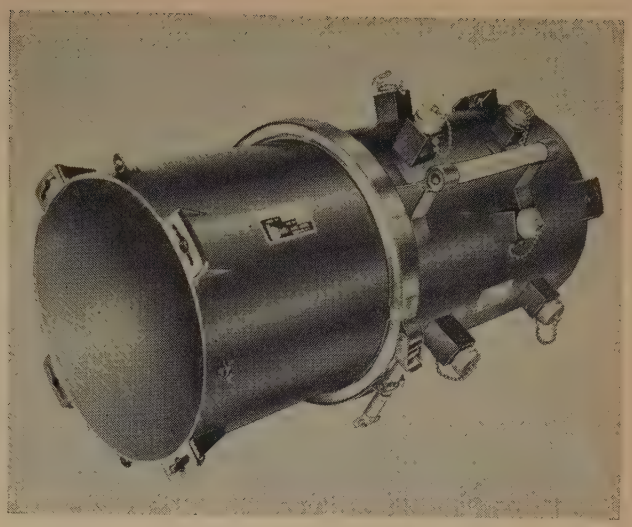

Figure 3 — A prototype coupler.

As an example, the calculated values of coupling for a specific condition in C-Band are listed below:

(For simplicity the horn is considered to be linearly polarized)

Equation 1	$C_1 = \frac{W_r}{W_t} =$	13 db
Relative power level of radiation pattern at angle θ for horn	$C_2 =$	15 db
Relative power level of radiation pattern at angle θ for stub	$C_3 =$	2 db
Cable attenuation (25 feet of RG-9B/U)	$C_4 =$	7 db
Total Coupling	$C_T =$	37 db

A prototype coupler, shown in Figure 3, was constructed as previously described, with a main body twelve inches in length; with the conical tapers attached, the maximum length was twenty-four inches.

To test the unit, a set of readily available antennas, which fit the requirements of the generic design, was used. The antennas had the following characteristics:

1. Maximum VSWR in free space of 1.50.
2. Maximum Power capacity of 500 Watts, C.W.
3. Half-power beamwidths between 45° — 100°
4. Circularly polarized, — with a maximum ellipticity of 3.5 db.
5. Bandwidths of approximately 40% — 50%.

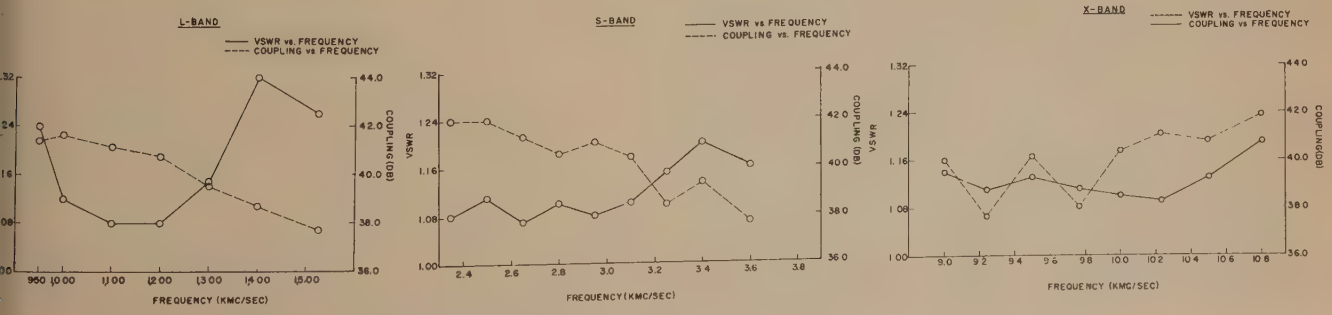

Figure 4 — Performance characteristics of coupler with circularly polarized antenna.

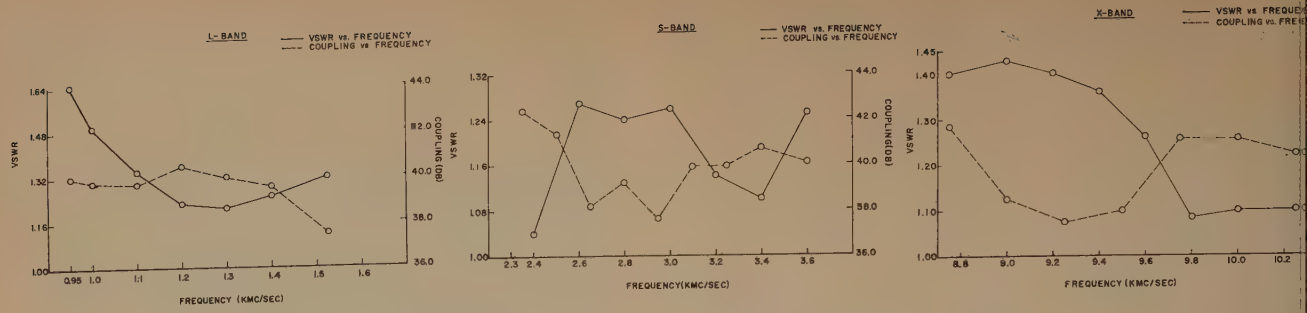

Figure 6 — Performance characteristics of coupler with scimitar antenna.

On the lower four bands the antennas are cavity recessed, top-loaded helices. The higher frequencies are covered by horns with dielectric phase-shifters.

Mounting blocks are provided for each frequency band at three discreet axial positions. The coupling is determined by stub depth and position. For convenience, each pair of blocks is set to a specific height so that a common pair of probes might be inserted to couple the nominal value of 40 db.

Figure 4 shows typical curves of VSWR and coupling vs. frequency in L, S, and X-Bands. Performance in the remaining bands is similar. Variation of coupling with relative axial rotation was measured at discreet frequencies in each band with twelve positions of rotation. In no instance did it exceed $\pm$ 1.0 db. High power tests were run at L and X-Bands, with approximately 350 watts of CW power, and at S-Band with 500 watts radiating into the coupler for over one hour. Maximum skin temperature was less than 250° F, and no physical deterioration of the coupler or antenna face was apparent.

For ease of handling, a carrying case can be provided to hold all the accessories including probes, cables, attenuator and tapers. The finished coupler weighed considerably less than twenty pounds.

A second class of antennas known as the "Scimi (Figure 5), was also tested with the coupler. Thiss tenna is characterized by extremely wide bandwic

Figure 5 — The "Scimitar" antenna.

linear polarization, and a pattern with consider energy radiating off to the sides. To obtain satisfac VSWR performance, the front tapers were replaced transitions with lossy linings; the loss was added absorb the energy radiated at low angles. Sample is shown in Figure 6.

Acknowledgment

The author wishes to thank Messrs. S. Lapidus and H. Buchanan for their contributions to the mechanical design of the units.

Abstract

Impedance adjustment effects on the noise figure of the 2K25 reflex klystron amplifier were examined experimentally and checked by theoretical equations. The noise figures were measured by the noise generator method applying various kinds of impedances to the reflex klystron amplifier. The noise figure varied over a wide range as the electronic and circuit impedances were varied. The lowest noise figure of 5 db was achieved under specially adjusted conditions operated in 9362 mc/s.

In order to have a low noise figure, the circuit impedance must be chosen so that the amplifier can stay out of the oscillation region of the Rieke diagram, and the electronic impedance must be adjusted so that the most desirable tuning can be realized at the operating frequency.

IMPEDANCE ADJUSTMENT EFFECTS ON REFLEX KLYSTRON AMPLIFIER NOISE

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Introduction

Application of a reflex klystron to a local oscillator of microwave receiver is one of the most common practices in microwave receiving system design. Proposals of the application of the reflex klystron to a microwave amplifier have been made and as far as gain is concerned, very promising results have been reported by several authors.[1, 2, 3, 4]

On the other hand, the reports on the noise figures of the reflex klystron amplifiers are not numerous and the values of noise figure reported do not always coincide with each other. The values spread over a range of 30 — 46 db depending on operating conditions and the type of the tubes used. In this paper the dependence of the noise figure of the 2K25 reflex klystron amplifier on impedance adjustments is discussed.

The 2K25 Reflex Klystron Amplifier

A schematic diagram of the 2K25 (723A/B) reflex klystron amplifier which was used for this research is shown in Figure 1. The input power excites the cavity through the coaxial cable and bunches the electron beam. The input power is amplified by the regenerative action of the bunched electrons and the amplified output power comes out of the coaxial cable and is taken from the right opening of the waveguide. In order to have stable, high gain operation, the external circuit impedance and the electronic impedance must be adjusted properly. The external circuit impedance is adjusted by the six screw tuners and one coaxial shorting plunger shown in Figure 1, and the electronic impedance is

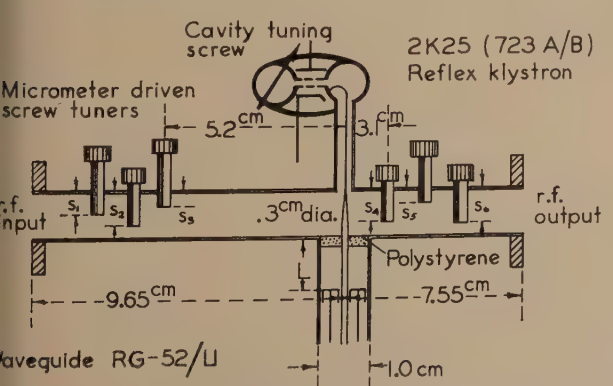


Figure 1 — Schematic diagram of 2K25 reflex klystron amplifier.

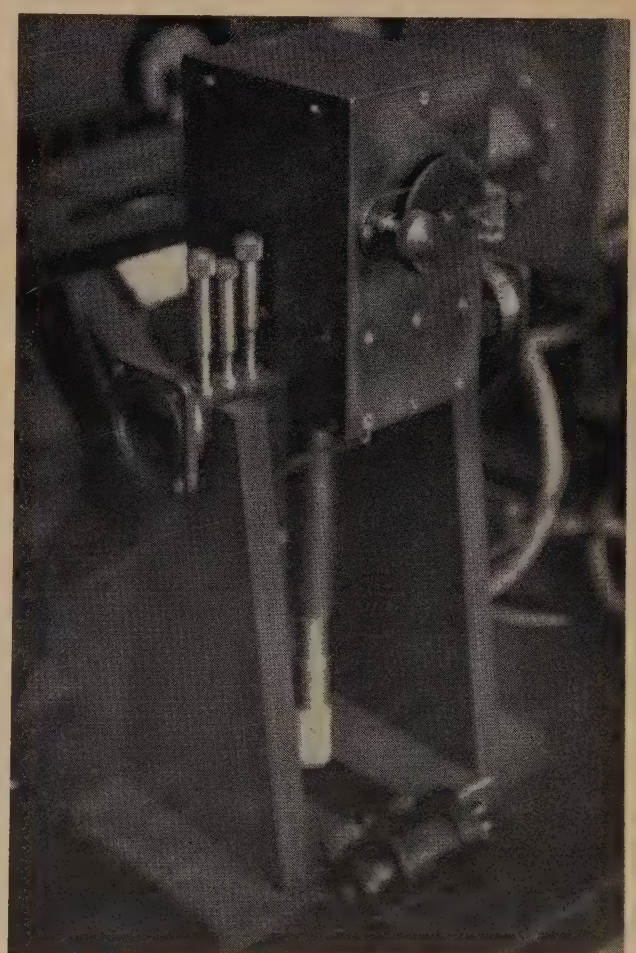


Figure 2 — Photograph of 2K25 reflex klystron amplifier.

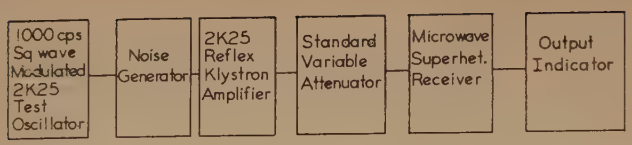


Figure 3 — Schematic diagram of noise figure measurement.

adjusted by the repeller and anode voltages of the tube.

A photograph of the 2K25 reflex klystron amplifier is shown in Figure 2. The six screw tuners and one shorting plunger, which have micrometer driving mechanisms for the impedance adjustment, are clearly shown. The dial shown on the box indicates the setting of the driving screw used to tune the cavity to the operating frequency.

III. Experimental Method

The noise figures of the 2K25 reflex klystron amplifier were measured by the noise generator method. A schematic diagram of the test circuit employed in this research is shown in Figure 3. The noise generator consists of an RCA 149A argon lamp in a proper waveguide mount (10°E type). The test oscillator output was fed to the amplifier through this noise generator tube to determine the amplifier conditions. The gain of this amplifier was indicated by the attenuator setting (Figure 3) which was adjusted to give the same amount of deflection to the output indicator when the amplifier was removed. When the amplifier was adjusted to measure the noise figure for any desirable conditions the test oscillator signal was turned off and the noise generator power alone was fed into the amplifier. In this case, the noise figure of the amplifier-receiver system is given by

$$F_{12} = 15.4 + \frac{M}{N - M} \text{ (db)} \qquad (1)$$

where:

N is the square low output indicator reading when the noise generator is on,

M is the output indicator reading when the input of the amplifier is terminated by a reflectionless termination,

and

15.4 db is the excess noise ratio of the RCA 149A argon lamp noise generator.

An isolator was sometimes used ahead of the amp to prevent any impedance variation during the mea ment.

If F_{12} is known, then the noise figure of the klystron, F_1, can be calculated by:

$$F_1 = F_{12} - \frac{F_2 - 1}{G_1}$$

Where G_1 is the gain of the amplifier and F_2 i noise figure of the receiver only, and can be mea in a similar way.

IV. Experimental Results

A. Circuit Impedance Adjustment Effect

Some typical examples among many experimenta sults of the impedance adjustment effects on the figure of the 2K25 reflex klystron amplifier are s in Table I. Even though the external circuit impe viewed from the grid gap of the klystron tube ca theoretically calculated,[5] it is almost impossible to me it in a practical situation. So, in Table I, various c conditions, such as screw tuner lengths, shorting pl position, and cavity tuning screw settings are listed in of showing the impedance itself. The values of inse loss and frequency bandwidth indicate indirectly how pedances are varied by these different kinds of c conditions.

For the case (a) in Table I, the amplifier was t at 9429 mc/s. Once the circuit conditions were as listed, no matter how the reflector voltage and a voltage were adjusted, the noise figure could not b creased less than 20 db. But this does not mean the imum noise figure of the reflex klystron amplifi 20 db. If the same amplifier tube is tested under d ent impedance adjustment conditions, then the figure is different. The cases (b), (c), and (d) ar results tested at 9362 mc/s using different impe adjustments. In the case (b), the noise figure wa creased to 11 db by choosing different settings o screw tuners, the shorting plunger, and the cavity ing screw. The noise figure was reduced to 6. by another setting of the impedance adjustmen shown in case (c) in Table I. In this case, however frequency band-width was sacrificed.

TABLE I

Circuit Impedance and Noise Figure of 2K25 Reflex Klystron Amplifier

Case	Conditions of External Circuit								Insert. Loss db	Band-width mc/s	Net Gain db	Nois Figu db
	S_1 mm	S_2 mm	S_3 mm	S_4 mm	S_5 mm	S_6 mm	1 mm	CTS deg.				
(a)*	0.	3.0	5.0	3.0	4.5	2.5	11.45	—	3.	10.	29	20
(b)**	1.36	2.46	0.	1.02	0.	0.	10.175	21	5.7	10	24	11
(c)**	1.54	9.9	0.	1.4	5.39	0.56	10.1	19.7	6.5	4	24.5	6.
(d)**	1.54	9.9	0.	1.4	5.39	0.56	10.65	19.2	14.	11.5	14.	5.

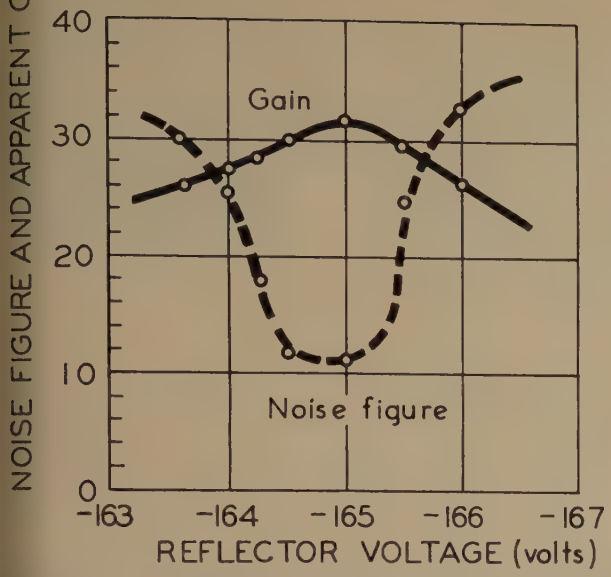
S_1 through S_6 Penetration length of the screw tuners to the waveguide.

1 Relative position of shorting plunger.

CTS Cavity tuning screw setting.

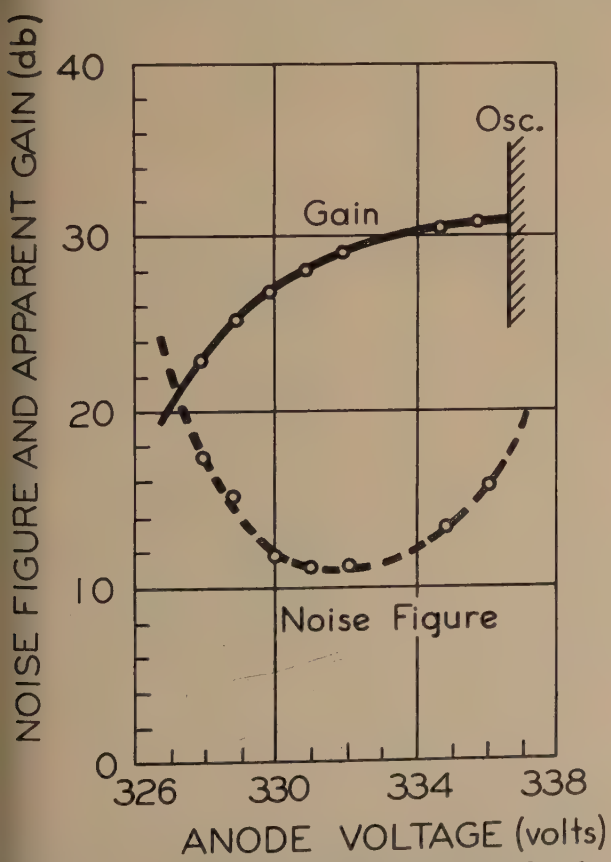
* Test frequency 9429 mc/s

** Test frequency 9362 mc/s



igure 4 — Noise figure and electronic tuning by reflector voltage (operating frequency: 9362 mc/s, anode voltage: 290 volts).

The screw tuner settings were the same for cases (c) nd (d), but the shorting plunger settings and the avity tuning screw settings were slightly different. hese slightly different settings affected the circuit im- edance considerably as is clearly shown in terms of the nsertion loss in Table I. For the case (d), the noise



igure 5—Noise figure and electronic tuning by anode voltage. (Operating frequency: 9429 mc/s, reflector voltage: —157.5 volts).

figure of 5 db was obtained, and here, particularly high insertion loss and relatively low gain, which indicate indirectly the particular impedance adjustment, were observed.

B. Electronic Impedance Adjustment Effect

When the external circuit conditions of the reflex klystron amplifier are fixed, the electronic impedance can be controlled by the anode, reflector and heater voltages. It is difficult to measure the electronic impedance viewed from the grid-gap of the tube directly. In this experiment, the electronic impedance variations were expressed indirectly in terms of either anode or reflector voltage variations.

Among many experimental results, three typical examples of the noise figures of the reflex klystron amplifier characteristics as a function of the electronic impedance adjustments are shown in the Figures 4, 5, and 6. In these figures, the gains are expressed as the apparent gains which include the insertion loss. Therefore, in order to obtain the net gain, the insertion loss, which is usually several db, must be subtracted from the apparent gain.

According to Figure 4, the noise figure is minimum when the gain is nearly maximum. In other words, when the electronic impedance is adjusted to obtain the maximum gain for a given fixed external circuit impedance by means of adjusting the reflector voltage, the noise figure is minimum. In this case, the electronic tuning is fairly good when the gain is maximum, so, the noise figure is low in this region.

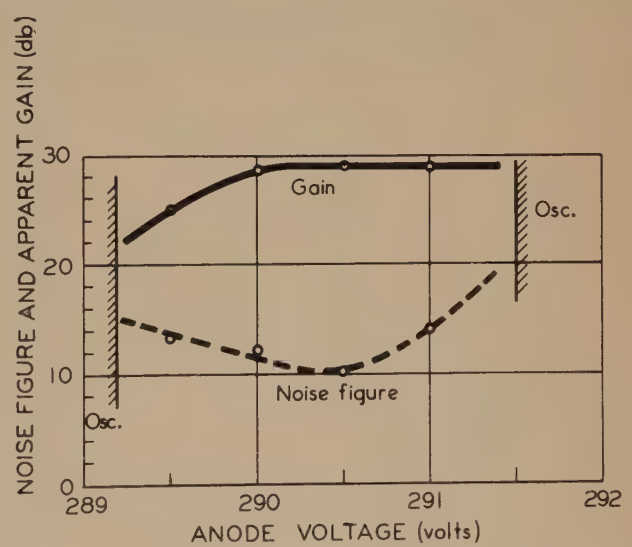


Figure 6 — Noise figure and electronic tuning by anode voltage (operating frequency: 9351 mc/s, reflector voltage: — 32.5 volts).

Another example is shown in Figure 5. The noise figure is minimum when the anode voltage is 332 volts. but the gain is not maximum in this case. When the anode voltage is increased, gain and noise figure are increased, because the self-oscillation region is approached. When the anode voltage is made less than 332 volts. the gain decreases and the noise figure increases, because of poor electronic tuning in this region.

The third example is shown in Figure 6. Here two oscillation regions are observed in the range of anode voltage adjustments. The minimum noise figure region exists between these two oscillation regions.

These experimental results show that the noise figure depends on the electronic impedance, and that the electronic impedance which gives fairly good electronic tuning can reduce the noise figure. On the contrary, an electronic impedance which gives either poor tuning or self-oscillation increases the noise figure.

V. Theoretical Considerations

Relations of the impedance to the noise figure of the reflex klystron amplifier can be expressed by several methods.

Haus and Robinson introduced an equation for the noise figure of any type of microwave beam amplifier in which an electron beam interacts with a longitudinal radio frequency field.[6] That is:

$$F_{min} = 1 + (4 - \pi)^{\frac{1}{2}} \frac{T_c}{T} \left(1 - \frac{1}{A_a}\right) \tag{1}$$

where:

T_c is the cathode temperature in °K,
T is the room temperature in °K

and

A_a is the available gain of the amplifier.

The impedance adjustment does effect the value of A_a. For the typical values of the 2K25 reflex klystron amplifier,

$A_a = 20$ db $= 100$
$T_c = 1000$°K,
$T = 300$°K,

then:

$F_{min} = 6.55$ db.

Beck[7] developed a noise figure equation for the two cavity klystron amplifier. If the equation is modified for the reflex klystron amplifier, it is: [4]

$$N.F. = 1 + \frac{T_a}{T} + \frac{20A\beta^2 I_o P^2}{G_c} \tag{2}$$

where:

T_a is the antenna temperature in °K,
β is the beam coupling coefficient,
I_o is the effective beam current in amperes,
P is the velocity modulation coefficient,
A is the gain of the amplifier,

and

G_c is the conductance of the circuit across the grids of the tube.

The relation of electronic and circuit impedances to the noise figure is expressed more explicitly in this equation than in Eq. (1).

For the 2K25 reflex klystron amplifier,

$T = T_a = 290$°K,
$\beta = 0.5$
$I_o = 5 \times 10^{-3}$ amperes.
$P = 1.5\%$
$A = 20$ db $= 100$
$G_c = 5 \times 10^{-4}$ mho,

then:

N.F. $= 5$ db.

Quate et al.[3] introduced a noise figure equation for the reflex klystron amplifier and that is:

$$N.F. = 1 + \frac{2eI_oR_L^2\delta^2}{kT_r} \tag{3}$$

where:

e is electronic charge,
R_L is circuit resistance across the grids of the tu
δ^2 is the reduction factor of noise current below noise,
k is Boltzmann's constant,

and

T_r is resonator temperature.

Values of R_L determine the noise figure in this case the 2K25 reflex klystron amplifier:

$T_r = 500$°K
$R_L = 2 \times 10^3$ ohm
$I_o = 5 \times 10^{-3}$ amperes
$\delta = 8\%$

then:

N.F. $= 6$ db

VI. Conclusions

The circuit and electronic impedance adjustments strong influence upon the noise figure of the reflex kly amplifier. In order to have low noise figure, the circui pedance and electronic impedance must be carefully ch so that the circuit impedance is adjusted to avoid self lation and the electronic impedance is adjusted to good electronic tuning to the operating frequency. T fore, the noise figure of the reflex klystron amplifie pends upon the kind of tube and the kind of tube m used. The 2K25 reflex klystron amplifier mounted particularly designed tube mount showed the noise f of 5 db under carefully adjusted impedance conditions a matter of fact, when this amplifier was used as a amplifier for the APS-3 receiver, the over-all sensi was improved 10 db. In other words, if the impedan carefully adjusted, the noise figure can be reduced so the reflex klystron amplifier can be used as a pre-amp to increase the sensitivity of the ordinary microwav ceiver. Theoretical examination agreed with the ex mental results.

VII. Acknowledgments

The author wishes to thank Professor E. H. Sch University of Wisconsin, for giving the opportunity this research and for his worthwhile advice. The au also wishes to acknowledge Professor S. Krupnik, and L. Heiting, Marquette University, for help in the pre tion of the manuscript.

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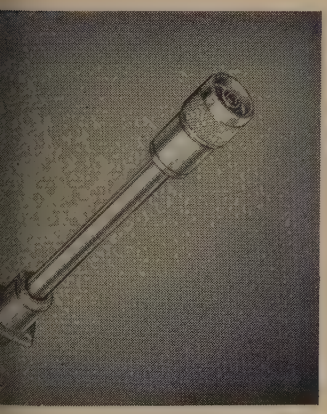

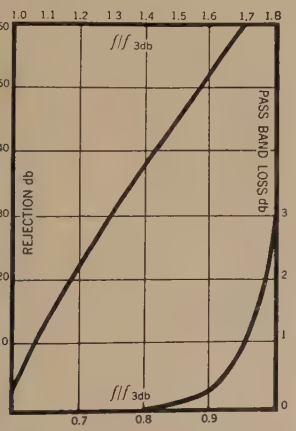

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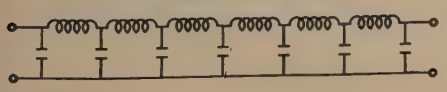

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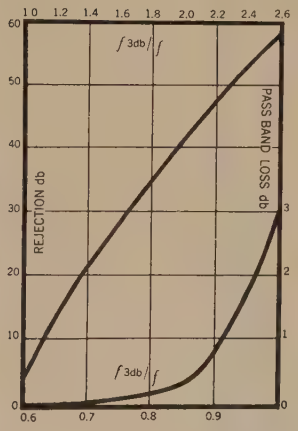

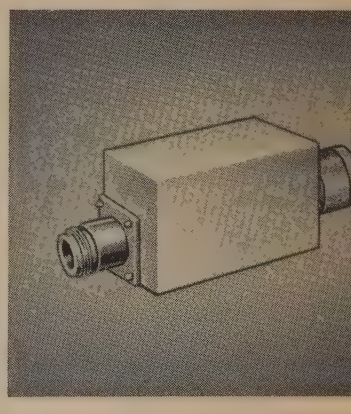

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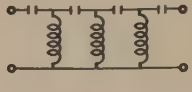

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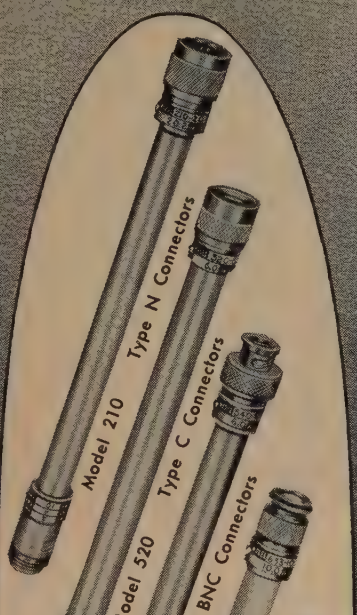
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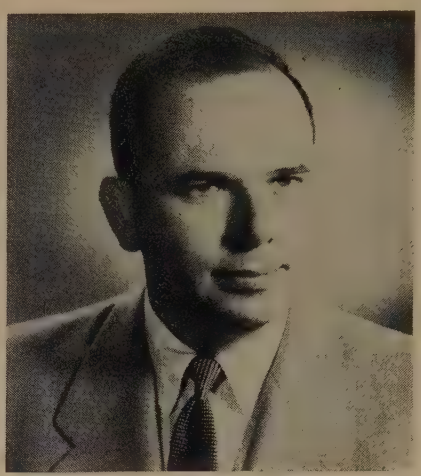
INDUSTRY NEWS . . .

MAGID NAMED TO HEAD FXR'S MICROWAVE PRODUCT ENGINEERING



Henry Feldmann, President of FXR, Inc., Woodside, N.Y., has announced that Milton Magid is joining the FXR engineering staff as Head of Microwave Product Engineering.

Milton Magid comes to FXR from the Hughes Aircraft Company, Culver City, Calif. He has been associated with Hughes since 1949.

Since November 1953 Mr. Magid has been Supervisor of the "Microwave Section of the Primary Standards Laboratory." This department of the Hughes organization has the prime responsibility of certifying the accuracy of the company's precision microwave components and equipment by developing advanced techniques and employing instruments known to conform to the primary standards maintained by the National Bureau of Standards. To this end the "Microwave Section of the Primary Standards Laboratory" engages in applied research leading to the establishment of new measuring techniques and the development of required instrumentation. Mr. Magid will establish techniques and procedures which will similarly assure the accuracy of all FXR precision microwave instruments and equipment.

Milton Magid is a Senior Member of I.R.E. and further affiliated with its "Instrumentation" and "Microwave Theory and Techniques" Professional Groups. He has been elected to Eta Kappa Nu, Tau Beta Pi and Sigma Xi honor societies and is an Associate Member of the Scientific Research Society of America (R.E.S.A.).

Mr. Magid received his B.S. degree (with honors) from the University of California at Berkley and his M.S. degree from the University of California at Los Angeles. His M.S. thesis earned a University Citation for excellence.

• • •

OVERSEAS SUBSIDIARY FOR VARIAN

Formation of a new subsidiary in Switzerland for Varian Associates is announced by Dr. Edward L. Ginzton, b chairman for the Palo Alto electr firm. The new company, Varian A. will have its main offices at Zug, wi research and applications laboratory Zurich.

Varian A. G., Ginzton said, will cilitate Varian Associates' participa in expanding markets for its prod abroad. He pointed out that Vari foreign business has expanded subs tially in all of its product areas inc ing microwave tubes, scientific ins ments, and high vacuum devices 1959 shipments up 40% over 1958.

Dr. Warren Proctor, who has re sented Varian Associates' instrument c sion in Europe since 1955, is manag director and chairman of the board Varian A. G. Other members of the firm's board of directors are Dr. H E. Frey, partner in the Zurich law of Niederer, Kraft & Frey, and Dr. wald Aeppli, legal adviser of Swiss Cr Bank.

Formation of Varian A. G. ma Varian Associates' first European sidiary.

Ginzton said the new company, Va A. G.. in addition to performing the f tions of marketing and servicing company's products in Europe, will c out significant research and developm work providing important cross fertil tion of ideas between American and eign scientists and engineers.

• • •

CRUCIBLE STEEL TO DEMONSTRA NEW ELECTROCHEMICAL ANO MATERIAL

A new material for electrochem anodes, titanium plated with a thin of platinum, will be demonstrated at 27th Exposition of Chemical Indust by the Crucible Steel Company America. Crucible, a pioneer produ of titanium, visualizes many uses these anodes but the largest poten use, replacement of graphite anodes chlorine-caustic cells, will be the demonstrated.

By coating titanium with platin less than 1/10,000 inch thick, titani can be made to act like a solid platin anode. Crucible believes this will pr valuable in cathodic protection, elec plating, control devices and in m electrochemical processes. The act demonstration will be in a pilot size phragm cell for chlorine-caustic desig by Hooker Electrochemical of Niag Falls, New York.

This novel anode may find large s use in the chlorine-caustic industry cause it will provide a maintenance- cell. Present graphite anodes are sumable-type and are consumed du operation of the cell. This causes pensive tear-down of cells, results higher operating voltages and leads contamination of the chlorine. This composite titanium-platinum anode e inates these disadvantages and appear provide savings in anode cost per to chlorine produced.

KEARFOTT MICROWAVE APPOINTS HUGHES

Mr. Willard A. Hughes has been appointed General Manager of the Microwave Division, Kearfott Company Inc., Van Nuys, California, manufacturers of precision microwave components and test equipment. The announcement was made by Mr. R. N. Brown, Vice President and General Manager of Kearfott Company, Inc., Little Falls, New Jersey, a subsidiary of General Precision Equipment Corporation.

Mr. Hughes brings to his new position, long managerial and engineering experience in the microwave field. He has served the Microwave Division for a number of years as Chief Engineer and, most recently, as Assistant General Manager. In his new capacity, Mr. Hughes has appointed Mr. D. F. Metcalf as Chief Engineer; Mr. N. P. Weinhouse as Manager of the Engineering Technical Office, and Mr. W. R. Biderman as Quality Control Manager for the Microwave Division.

• • •

I-T-E DOUBLES PRODUCTION FACILITIES FOR GIANT RADAR, MICROWAVE ANTENNAS

Completion of a new 50,000 square foot building has doubled facilities for producing and testing giant radar and microwave antennas and systems at the Special Products Division of I-T-E Circuit Breaker Company, Philadelphia.

The new facility, completed on a rush basis in 60 days after pouring of foundations, simplifies and speeds assembly of huge antennas and centralizes under one roof all operations required in assembling major components into finished systems.

The expansion of facilities was required to meet the increased demand for such antennas as those for the DEW-line Extension, the Ace High NATO communications network and TACAN automatic position-finding system. I-T-E orders for such equipment have risen more than 30 percent in the past year.

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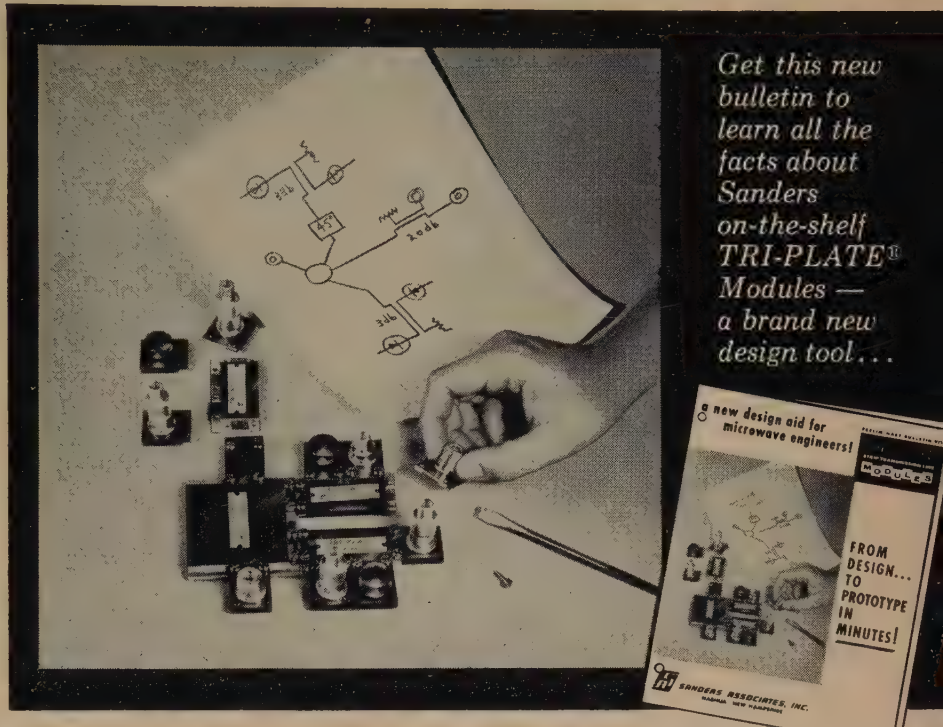
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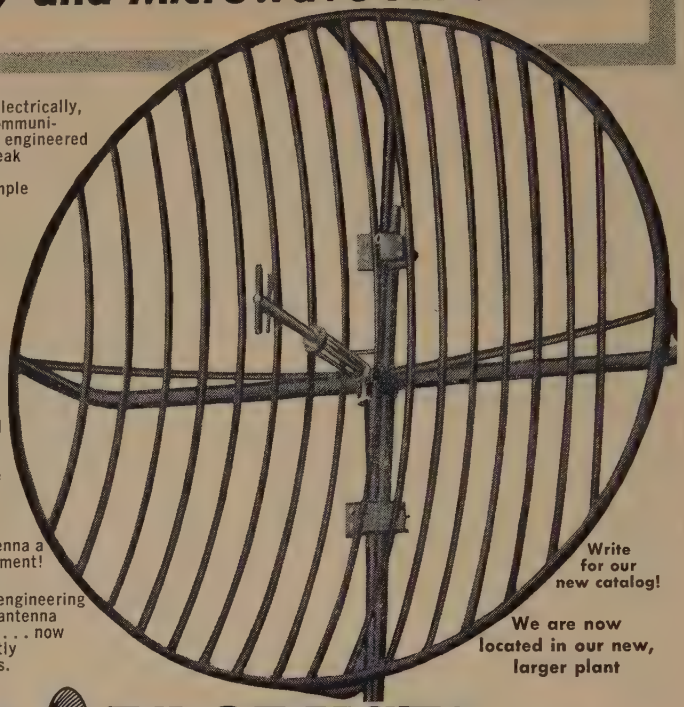

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Antennas produced in the new f ity will range in size up to huge si welded structures 60 feet long and feet high used as reflector screens for search antennas of the DEW-Line tension.

Less bulky items include the preci gear trains which are incorporated antenna pedestals to provide the ante driving power.

Some of the microwave antennas duced in the new Special Products f ity will be used in the Ace High NA communications system which will str from northern Norway to eastern key. The TACAN equipment assem here will permit aircraft to deter position automatically and instant ously through signals to a network ground stations.

Other types of radar assembled at new plant will include meteorolog systems for use by Weather Bur throughout the country, to detect give early alerts for storm moveme stationary radars for airport surveill duty and naval search systems for s board use.

• • •

SCIENTIFIC-ATLANTA, INC. PURCHASES 64 ACRE TRACT FOR FUTURE EXPANSION

Scientific-Atlanta, Inc., Georgia ma of microwave instrumentation, has c pleted the purchase of sixty-four a of land in Gwinnett County adjacen the Atlanta-Gainesville expressway. tract, recently rezoned for industrial lies just outside of the city limits Norcross and will be used for expan of the electronic company's manufac ing facilities, now located at 2162 P mont Road, N.E.

In making the announcement, C P. Robinson, Jr., President, pointed that the company had grown from employees in the summer of 1957 125 at the present time. Mr. Robi added, "the fast moving electronic dustry demands that our growing c pany plan well in advance for the f ities to produce the new instrum being developed under our research gram. We have had several overt from other communities about exp ing in other areas. However, we that this area of Gwinnett County enable us to spread out and still e the advantages of Atlanta that have far been so important to our grow

Seller of the tract was Mrs. Elsi Russell. The sales price was not closed.

HEWLETT-PACKARD NAMES ARBUCKLE

The Hewlett-Packard Company board of directors recently elected Ernest C. Arbuckle to the board.

Mr. Arbuckle fills a vacancy created by the recent death of Charles R. Blyth. Mr. Blyth had served as a director of the Palo Alto electronics manufacturer since February 1958.

Mr. Arbuckle graduated from Stanford University and is presently Dean of the Stanford Graduate School of Business. Prior to that he was a vice-president of W. R. Grace and Company, Central America and an executive vice-president of that firm's Pacific Coast and Foster-Kleiser Divisions.

He is a former member of the Stanford University Board of Trustees, and presently serves on the Governing Board of the United Crusade. In addition Mr. Arbuckle is a director of the Republic Supply Company, Insurance Investors Fund, Western Machinery, California Ink Company, and the Foster-Kleiser Division of W. R. Grace and Company.

Continuing members of the Hewlett-Packard board are: David Packard, W. R. Hewlett, W. S. Cavier, Dr. Frederick E. Terman, Dr. Luis W. Alvarez, Harold H. Buttner, Thomas P. Pike, and H. Rowan Gaither, Jr.

• • •

30-MILLION-WORDS-A-SECOND COMMUNICATIONS POSSIBLE WITH NEW MICROWAVE DEVICES

Sperry scientists have created several electronic devices capable of handling information at the rate of 30 million words per second, it was reported here today by a Sperry Gyroscope Company engineer at a meeting of the IRE Professional Group on Electronic Computers.

Peter J. Isaacs, Sperry's head of digital computer research said that the new devices were created for the purpose of developing computers and communications systems capable of handling large amounts of information at speeds at least 1000 times faster than large electronic computers currently in use.

"The earliest use of these new high-speed techniques will be in systems simpler than computers," Isaacs predicted. "An immediate possibility arising is development of a special communications system in which a message of say 30 words, such as a telegram, could be transmitted in a millionth of a second. A system of this kind could transmit the complete message on a single radar pulse," he said.

"Another possibility is in a data reduction system involving simple operations as correlating and counting, such as in scientific experiments in nuclear physics where billions of events occur in an extremely small space of time," he said.

Isaacs described a microwave diode switch capable of switching 700,000,000 bits of information a second. The device uses hollow pipes as conductors in place of conventional wires because it employs 10,000-megacycle alternating energy instead of the standard d-c electric currents used in present computers.

Another component described is a new microwave amplifier tube which can perform logic operations at the rate of 1,000,000,000 times a second. The device employs a radio wave traveling down an electron beam to cause one microwave signal to control another microwave signal. Logic circuits employing these devices have operated successfully in the Sperry computer laboratory to perform combinations of logic decisions such as "and," "or," and "not," Isaacs reported.

Devices, such as the microwave amplifier tube, are not necessarily limited to our present laboratory experimental rates of 1,000,000,000 bits per second because even now we have the technological experience to build them for speeds five to seven times greater, he said.

When the new techniques are used for computers, presumably only a small fraction of the computer would have to operate at the ultra-high speeds. Techniques for transferring information between microwave and standard circuits have already been developed.

Sperry scientists contributing to the research include W. Sauter, I. Itzkan, Dr. C. C. Wang, P. R. McIsaac, D. Abraham, S. M. Freeman and P. J. Isaacs. The work was performed in the laboratories of the company's Electronic Tube Division, Surface Armament Division, and Aeronautical Equipment Division.

• • •

FXR OPENS N.E. REGIONAL OFFICE

FXR, Inc. announces the opening, November 1, 1959, of its new regional office at Lincoln Road, South Lincoln, Mass. (P.O. Box 92) with Robert L. Diamond, Regional Sales Manager, in charge.

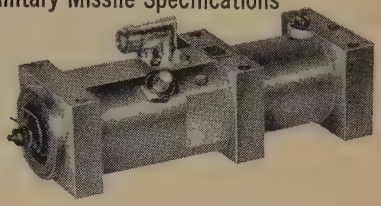
This centralized location on the outskirts of Boston and an increased staff is intended to broaden FXR's service throughout the entire New England area, according to FXR's President, Henry Feldmann.

The company is a leading designer and manufacturer of precision microwave equipment, high-power pulse modulators and high-voltage power supplies.

NEW!

S-Band *System-Tested*
MICROWAVE COMPONENTS

Engineered to meet complete Military Missile Specifications



S-BAND PULSE OSCILLATOR

- Minimum 1.5 KW Peak Power Output at .001 duty cycle; 1 μsec pulsewidth 1000 pps
- 300 MC Tuning Range
- Operating Conditions: 3000V at 2.5 amp peak (nominal)

S-BAND CW OSCILLATOR

- Minimum 50 mw Power Output 100 mw at lower frequencies
- Exceeds 400 MC Tuning Range
- Operating Conditions: 125V-250V at approx. 20-35 ma depending on plate voltage.

Both oscillators are lightweight (only 20 oz.) with integrated mountings. Both use 6442 triode tube. Heater 6.3V AC or DC.

S-BAND FILTER-MIXER-DIPLEXER

- Mixer and Diplexer (non-tunable) operate as an integral part of the Filter
- Unit features minimum Insertion Loss, Rejection Bandwidth and Input VSWR.
- Tuning Range: exceeds 300 MC

WRITE for prices and delivery

AVION
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acf INDUSTRIES INCORPORATED
AVION DIVISION
11 Park Place, Paramus, N. J.

CIRCLE READER SERVICE CARD 30

Dept. of Commerce Reports Rise In Electronic Components Shipments

First half 1959 shipments of electron tubes, semiconductors, and other principal electronic components increased more than 15 percent over the preceding 6 months, and were in excess of 30 percent above the comparable period in 1958, the Electronics Division, Business and Defense Services Administration, U.S. Department of Commerce, reported.

This sharp rise, the greatest since the Korean War period, confirms employment trends and other general indicators of steadily growing electronics output during the past 9 months. The trend is expected to continue through the rest of the year. Although all components shared in the upward movement, there were marked differences in their rates. Semiconductor shipments ing the first half of 1959 were more than double t of the first half of 1958, while receiving tube shipm increased only 5 percent.

The following excerpts, which give details by ponent category, were derived from the semi-annual J Survey of Production Capabilities for Electronic Parts ducted by the Electronics Production Resources Age Department of Defense, and the Electronics Divis BDSA. The data presented, however, represent estim total industry shipments rather than aggregates of survey data. The data were prepared to aid industry market programming.

ESTIMATED SHIPMENTS OF ELECTRON TUBES AND SEMICONDUCTORS DURING THE FIRST HALF OF 1959

Category	Quantity in thousands of units			Value in millions of dollars		
	Total	Military	Nonmilitary	Total	Military	Nonmilit
Power and special purpose tubes	5,751	1,702	4,049	124.7	87.5	37.2
High vacuum tubes	2,007	938	1,069	30.5	16.9	13.6
Gas and vapor tubes	790	317	473	7.4	3.2	4.2
Klystrons	123	109	14	19.2	17.0	2.2
Magnetrons	41	38	3	23.6	23.0	.6
Forward and backward wave tubes	5	4	1	13.6	13.1	.5
Duplexer tubes	101	94	7	3.7	3.6	.1
Light sensing and emitting tubes	736	114	622	12.4	5.2	7.2
Storage tubes	3	2	1	3.4	2.6	.8
Other [1]	1,945	86	1,859	10.9	2.9	8.0
Semiconductor devices	93,880	22,723	71,157	177.2	74.4	102.8
Germanium diodes and rectifiers	29,352	6,703	22,649	17.3	4.8	12.5
Silicon diodes and rectifiers [2]	28,055	10,413	17,642	59.6	28.3	31.3
Transistors	36,473	5,607	30,866	100.3	41.3	59.0

ESTIMATED SHIPMENTS OF SELECTED ELECTRONIC COMPONENTS, EXCEPT TUBES AND SEMICONDUCTORS DURING THE FIRST HALF OF 1959

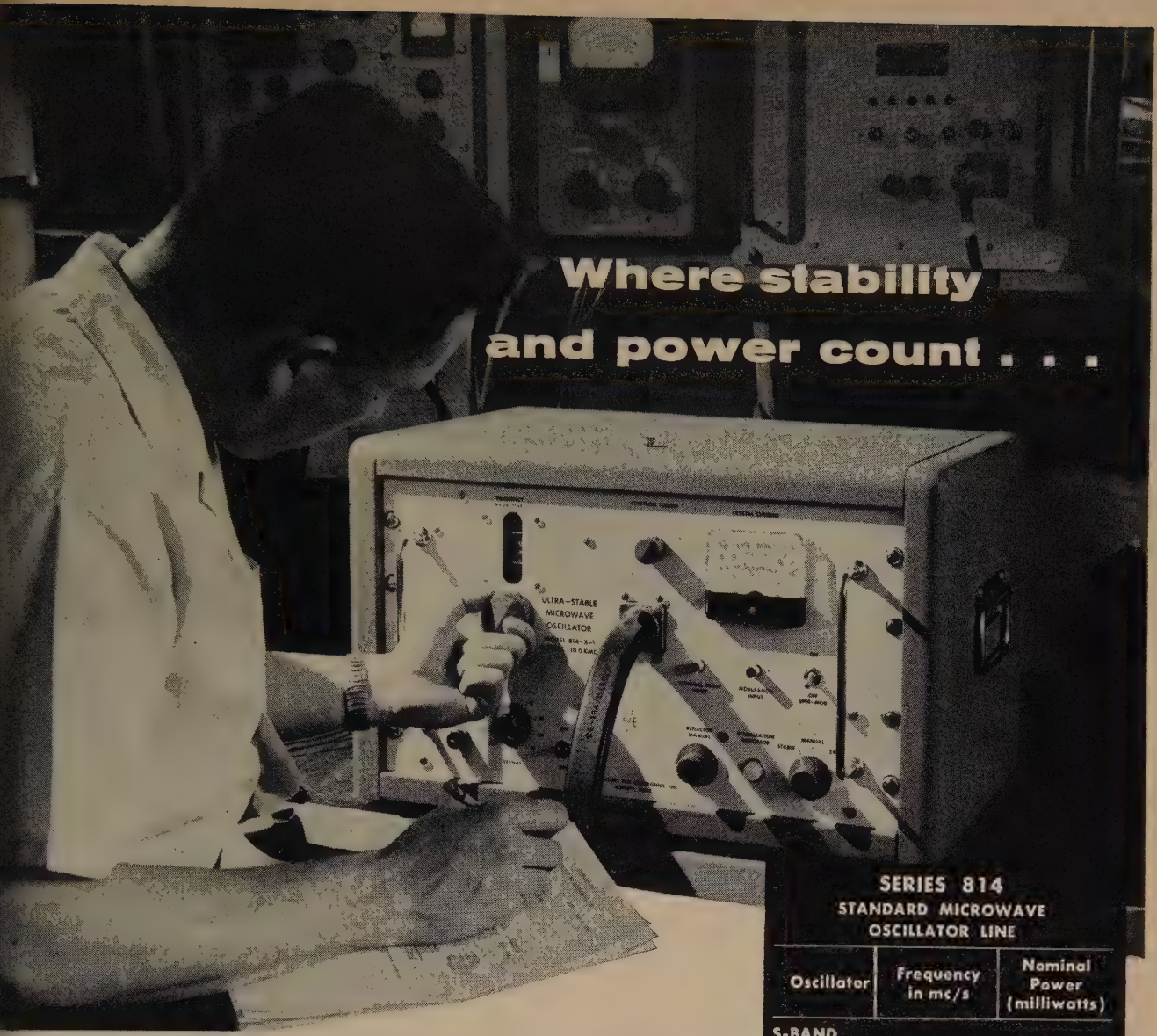
Category	Quantity in millions of units			Value in millions of dollars		
	Total	Military	Nonmilitary	Total	Military	Nonmili
Connectors	41.4	26.6	14.8	69.8	49.1	20.7
Coaxial (r-f)	10.8	6.5	4.3	7.9	4.2	3.7
Cylindrical	14.2	9.8	4.4	32.2	25.5	6.7
Multiple contact (rack and panel)	8.3	4.7	3.6	14.1	8.3	5.8
Fusion sealed	.9	.7	.2	2.0	1.5	.5
Printed circuit [3]	2.6	1.9	.7	2.9	1.9	1.0
Other	4.6	3.0	1.6	10.7	7.7	3.0
Relays (for electronic applications)	11.7	4.5	7.2	85.2	45.1	40.1
Electromagnetic, except coaxial and stepping switches						
Through 100 mw. actuating power	1.0	.4	.6	8.9	4.2	4.7
Over 100 mw. actuating power	6.9	2.7	4.2	44.2	26.9	17.3
Telephone types	2.0	.7	1.3	13.7	5.0	8.7
Other [4]	1.8	.7	1.1	18.4	9.0	9.4

[1] Includes UHF planar (lighthouse) tubes; radiation detection tubes; spark gaps; beam deflection tubes; decade counters; electronic switches; orbital beam tubes; and vacuum capacitors, switches and gauges; excludes X-ray tubes.

[2] Includes power rectifiers, light sensitive devices, and mixer crystals; excludes selenium and copper oxide rectifier stacks.

[3] For printed circuit board and cable applications.

[4] Includes coaxial, stepping switches, thermal, meter movem motor driven, and other relays.



Where stability and power count . . .

If you have an application where stability and power output requirements are *really* exacting (production or testing of microwave components of air defense missile systems, for example), it's to your advantage to investigate LFE Series 814 Microwave Oscillators. They have been tried and proven in all fields of microwave work over a period of 7 years.

STABILITY — Series 814 Oscillators are ultra-stable. Average short term frequency stability (residual) is five parts in 10^8. Average long-term stability is one part in 10^6. A self-contained invar dual mode reference cavity and AFC loop insures this performance. When a frequency is selected via the reference cavity, and the Klystron locked to it, stability characteristics conform to the above specifications. Klystron is conveniently locked by observing a stabilization indicator light bringing about great ease in operation.

POWER — The table on the right tells the power story. Nominal powers available in standard Series 814 Oscillators range from 20 to 500 milliwatts. Outputs up to 1.5 watts are available on special order.

SPECTRUM COVERAGE — Series 814 is a complete line, covering the microwave spectrum from 2500 to 26,000 megacycles.

AMPLITUDE MODULATION — Up to 15% by internal 1 kc oscillator, jack on front panel for external modulation.

FREQUENCY MODULATION — Deviation up to 0.01% of selected frequency via external connector.

SERIES 814
STANDARD MICROWAVE OSCILLATOR LINE

Oscillator	Frequency in mc/s	Nominal Power (milliwatts)
S-BAND		
814-S-1	2500-3050	75
814-S-2	2950-3600	80
814-S-3	4200-4800	70
C-BAND		
814-C-1	5100-5900	60
814-C-2	5800-6600	65
814-C-3	6300-7125	55
814-C-4	7125-8125	80
814-C-5	7500-8500	90
814-C-11	5700-6300	200
814-C-12	6200-6900	250
814-C-13	6800-7400	300
X-BAND		
814-X-1	8500-10,000	80
814-X-2	9000-10,500	55
814-X-3	9800-11,200	70
814-X-4	10,500-11,700	80
814-X-21	8500-10,000	500
K-BAND		
814-K-1	13,000-14,000	20
814-K-2	16,000-17,000	40
814-K-11	12,000-13,800	85
814-K-12	14,000-16,000	25
814-K-13	15,500-17,500	30
814-K-21	12,800-14,500	100
817-K-25	24,000-26,000	30

WRITE FOR BULLETIN 814-A

LABORATORY FOR ELECTRONICS, INC.

INSTRUMENTS AND COMPONENTS SALES
75 PITTS STREET, BOSTON

CIRCLE READER SERVICE CARD 31

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PRECISION
MEASUREMENTS
from 50 to
10,500 MCS

WEINSCHEL

100% Square Wave
MODULATED RF SOURCES
Offer High Amplitude
and
Frequency Stability

Model MS-6

Output Amplitude Independent of Load

Feedback circuit maintains constant incident power, allowing use of full generator output without power consuming impedance masking.

Amplitude Stability

After one hour warm-up and without feedback circuit: ± 0.1 db/hr. With regulator and external directional coupler, the incident power will change less than 0.2 db for a change in load of from 25 to 150 ohms. With a voltage probe, the **voltage variation** is reduced by 10:1 by feedback.

Model No.	Frequency MCS	Minimum Peak Power Output (100% Sq. Wave Modulated)
MS-1	50-250	80MW
MS-2	250-920	200MW
MS-3	900-2000	100MW
MS-4	2000-4200	60MW
MS-5	4000-7300	40MW
MS-6	7200-10,500	30MW

Write for complete specifications.

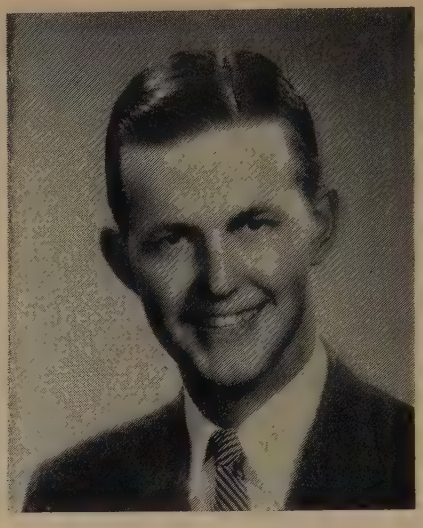
Weinschel Fixed Coaxial Attenuators cover the frequency range of DC to 12 KMC. Write for complete catalog, specifying frequency range of interest.

WE CO

Weinschel Engineering
KENSINGTON, MARYLAND

CIRCLE READER SERVICE CARD 32

SYLVANIA APPOINTS SWANSON MICROWAVE PRODUCT MANAGER



Roger A. Swanson of Winchester, Mass., has recently been appointed product Manager, Microwave Sales for the Semiconductor Division of Sylvania Electric Products, Inc., in Woburn.

Prior to his joining Sylvania, Mr. Swanson served in engineering capacities with Westinghouse Electric Corp., at Springfield, Mass., and with E. I. du Pont de Nemours & Co., at Niagara Falls, N.Y.

He is a graduate of Harvard College with a bachelor of science degree in electrical engineering and received a master's degree in business administration from the Harvard Graduate School of Business Administration in 1956.

He is a member of the American Management Association and the Institute of Radio Engineers.

• • •

DEMAIO JOINS CORNING

Corning Glass Works announced today that Joseph S. DeMaio has joined the company as advertising and sales promotion manager of the Electrical Products Division.

He has been associated with the R. H. Donnelly Corp. and the National Gypsum Co. of Buffalo, N.Y., and The Carborundum Co. of Niagara Falls, N.Y.

He received a bachelor's degree from Syracuse University in 1952. He served with the U.S. Army from 1952 to 1954.

• • •

FIRST PRECISION ANTENNA

A new antenna system — first for a nationwide network of 39 high-power storm-finding radars that promises to usher in a new era in weather forecasting — has been delivered to the Miami, Fla., Weather Bureau by I-T-E Circuit Breaker Company, Philadelphia.

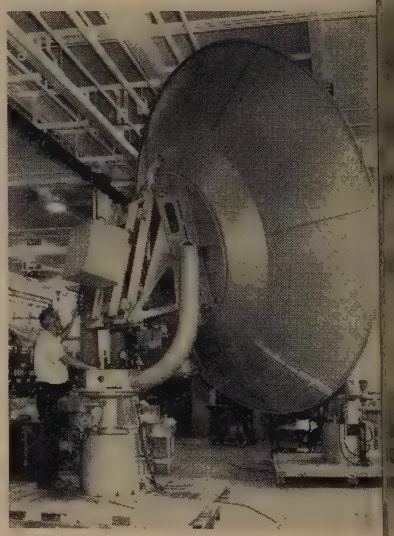
The antenna is the sky-scanning unit for a new type radar — designed specifically for meteorological use — which can locate and track storms over an area of 200,000 square miles and provide virtually instantaneous data on direction, size, intensity, speed and height.

The radar has a maximum range of 250 miles, a three-fold increase over all tracking radars converted for weather service.

The new radars are being produced for both the Weather Bureau and the Navy by Raytheon Co., Waltham, Mass. I-T-E's Special Products Division is building the antenna systems under subcontract from Raytheon.

Completion of the network is scheduled for July 1960. The Weather Bureau hopes to have part of the East Coast, Seaboard and Gulf Coast storm warning network in operation by this fall — before the peak of the hurricane season.

The Miami installation — now undergoing extensive tests — will be followed by installations at Apalachicola, Fla., Washington, D.C., New York City, Brownsville, Tex., and Wilmington, N.C.



The antenna system for the storm finder — designated WSR-57 — is extremely light in weight and versatile both electronically and mechanically.

The antenna incorporates a piggy-back radio-frequency head to supply r-f energy to the antenna. This unit fits directly behind the antenna reflector — eliminating the need to change the complete waveguide run, should it be desired to change the frequency.

The storm finder is now designed to operate in the "S" ultra-high frequency band. It can be converted for operation at "X" or "C" band frequencies by changing the r-f head. A servo system remotely controls antenna position in any mode of operation. It provides for normal slewing, tracking, azimuth and elevation scanning functions.

The lightweight antenna system utilizing a 12-foot spun aluminum parabolic reflector and a cast aluminum supporting yoke — weighs less than 2,000 pounds.

MOTOROLA APPOINTS FAVREAU MILITARY REGIONAL EPRESENTATIVE ON WEST COAST

Nelson J. Favreau has been appointed egional Representative on the West oast for Motorola's Military Electronics ivision, Paul J. Sturm, Division Mark- ting Manager announced.

Favreau will assist Gordon J. Knoob, lanager of the West Coast Representa- ives Office at Hollywood, Sturm said. A nine-year veteran with Motorola avreau joined the company in Chicago ollowing graduation in electrical engineering from DeVry Technical Institute. He also studied business administration at Bliss College.

Subsequent positions with Motorola included quality control engineer and later field engineer and technical consultant to Robins Air Force Base on radar systems.

• • •

LITERATURE . . .

MICROWAVE INSTRUMENTS AND COMPONENTS CATALOG

The new 120-page Alford Manufacturing Company Instruments and Components Catalog contains detailed information on the expanding line of AMCI products. Shown are slotted lines and tapered reducers, automatic impedance plotters, coaxial switches, transmission line hybrids, instrument loads, adjustable matching networks and impedance standard lines.

In addition to technical descriptions, pictures, outline dimensions, circuit diagrams, and electrical and mechanical characteristics, the catalog includes a summary of data on transmission line connectors, complete price lists, suggestions for ordering and a list of sales representatives.

CIRCLE READER SERVICE CARD 101

NEW CATALOG AVAILABLE FROM PULSE ENGINEERING

A catalog and application manual of pulse transformers is now available from Pulse Engineering, Inc. of Santa Clara, California.

Twenty-four pages in length, the profusely illustrated catalog contains sections on definitions, ordering information, pulse transformer theory, applications aids, testing and inspection tolerances, miniature and subminiature pulse transformers, pulse modulation and magnetron transformers, and list of Pulse Engineering representatives.

CIRCLE READER SERVICE CARD 102

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TRANSISTORIZED C-BAND RADAR BEACON

Publication WCP59-0812, 8 pages, describes General Electric's C-band radar beacon, a 9.8 pound, airborne, pulse-type missile tracking and identification aid designed particularly for operation with AN/FPS-16 radar and also compatible with the AN/MPS-26 and several other C-band radars. Beacon characteristics such as its 400-watt output capability, application flexibility and compact size are discussed. A full product description, development history, and complete specifications are included.

CIRCLE READER SERVICE CARD 103

ALL SIZES
MS FLANGES
IN STOCK

THE FINEST QUALITY BRASS AND ALUMINUM STANDARD WAVE-GUIDE FLANGES in stock at Formcraft—all precision made to military standards. For rigid and flexible waveguides.

Special flanges to your specifications. Send sketch or blueprint for a quotation.

SEND FOR NEW BROCHURE #14B
DESCRIBING AND ILLUSTRATING ALL THE STOCK FLANGES

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CIRCLE READER SERVICE CARD 33

NEW! THE MERCURY "10" SERIES
TRIODE CAVITIES

10% tuning range

Fully standardized line for design and production . . . Frequency range from 225mc to top existing tube limits

DELIVERY—30 DAYS OR LESS!

Only JVM offers these outstanding engineering advancements—low cost standardized production—off-the-shelf availability—design flexibility and uniform performance.

Miniaturized MERCURY "10" cavities are precision engineered for restricted tuning range, minimum weight-frequency stability and temperature compensation. The "10" series includes 720 different cavities designed for maximum power and/or voltage ratings of a variety of tubes.

Call or write for engineering drawings and specifications.

J-V-M MICROWAVE CO.
9303 W. 47th Street Brookfield, Illinois HUnter 5-2000
TWX Brookfield, Ill. 2796

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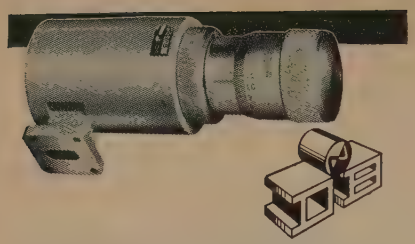

BROAD BAND CAVITY WAVEMETERS

—gas filled for sustained accuracy

Accuracy is so high these instruments may be used as secondary standards. Units are unaffected by changes in humidity, altitude or barometric pressure. Only 12 sizes serve from 2.6 KMC to 140 KMC. You save budget money on the number of sizes needed. Literature on request.

DE MORNAY BONARDI

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780 SOUTH ARROYO PARKWAY • PASADENA, CALIF.

CIRCLE READER SERVICE CARD 35

GENERAL BRONZE CORPORATION RELEASES TWO SCATTER ANTENNA SYSTEM RESEARCH PAPERS

The research publications office of the General Bronze Corporation electronic division at Valley Stream, New York, announces that two papers on scatter antenna system research are now available.

These papers, entitled: "Design considerations on modern scatter systems" and "Far field patterns of circular paraboloidal reflectors," represent the compiled data on research programs conducted at General Bronze under the direction of Mr. George Doundoulakis, director of research.

These works written by Mr. Doundoulakis and Mr. Stanley Gethin, display original designs for scatter antenna systems and present an important new recommendation for future scatter antenna paraboloidal installations.

As long as supplies last, either or both of these papers will be sent free of charge upon request.

CIRCLE READER SERVICE CARD 104

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BULLETIN ON MEASUREMENT TECHNIQUES ISSUED BY JERROLD ELECTRONICS CORPORATION

Time saving measurement techniques through the use of a coaxial switch is the subject of a four-page Technical Newsletter published by the Industrial Products Division of Jerrold Electronics Corporation.

The bulletin describes how, with the need for costly, time consuming "set ups" and "take downs," the Jer Coaxial Switcher, Model FD-30, can used for comparison measurements in frequency range from D.C. to 250 These measurement techniques, furt more, avoid the problems of detector amplifier balancing.

The Technical Newsletter uses pict and charts for a detailed description measurement techniques.

CIRCLE READER SERVICE CARD

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TWO NEW BULLETINS DESCRI WEINSCHEL FIXED COAXIAL ATTENUATO

Weinschel Engineering of Kensing Maryland, has recently released two page, two-color brochures on fixed axial attenuators.

The first, Bulletin No. 44, descr Model 50, D-C to 1 KMC Fixed Coa Attenuators which are available Type N, C, or SC connectors, each in male/female, double male, or do female combinations.

Bulletin No. 17R describes Weinsch series of 1 to 12.4 KMC Fixed Coa Attenuators. These attenuators are av able with Type N, BNC, TNC, C, or connectors, each type in male/fem double male, or double female comb tions.

Both bulletins contain complete sp fications, prices, and curves of VS and insertion loss as a function of quency. Copies of Bulletins 44 and are available upon request.

CIRCLE READER SERVICE CARD

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TRANSFORMER BULLETIN FRO STAVID

"Transformers for The Electronics dustry," a 4-page bulletin describing company's line of high-power pulse tra formers and inductor devices is offe by Stavid Engineering, Inc. of Plainfi New Jersey. Specifications on pulse tra formers and charging reactors to 100 output with 10-ampere filament supply included in the new bulletin.

CIRCLE READER SERVICE CARD

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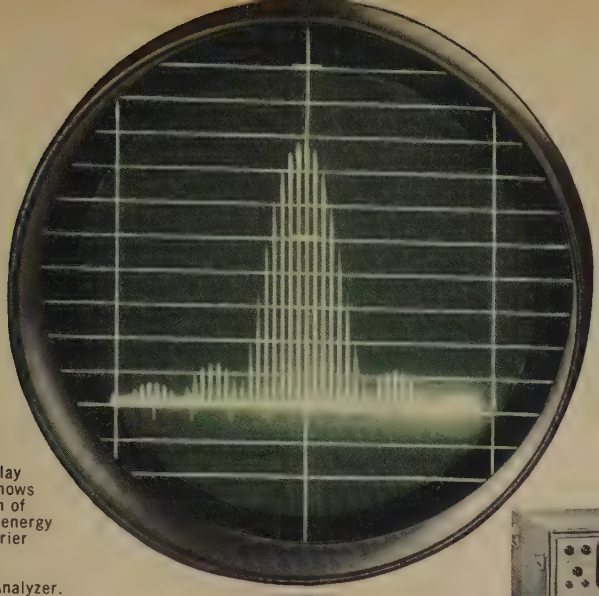
TECHNICAL DATA ON LOW TEMPERATURE FIELD PUBLISHE FOR THE FIRST TIME

Until recently, no literature was ava ble on research in the field of ultra l temperature. But now, for the first ti a book has been published that co the subject in detail and presents v current information.

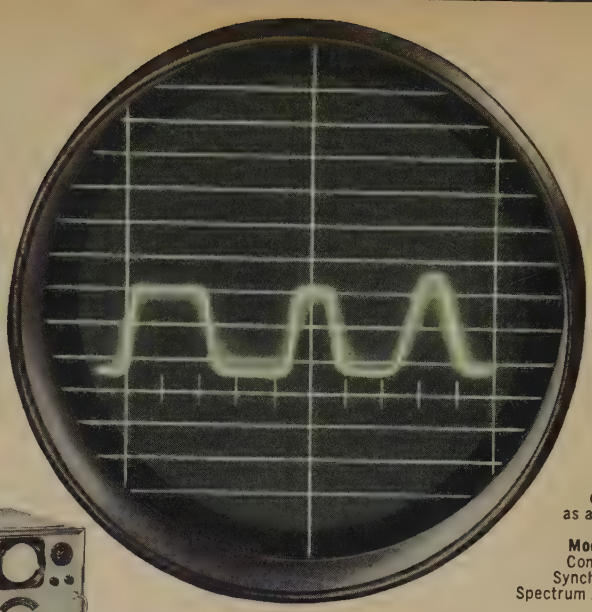
This scientific 44 page book, publish by Hofman Laboratories, Inc. discus developments in low temperature chem try, solid state physics, superconductiv metallurgical research, maser resear microwave spectrometry, etc. Hofm

(*Continued on page 59*)

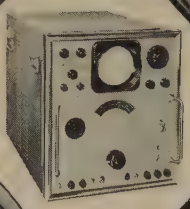
CIRCLE READER SERVICE CARD 36

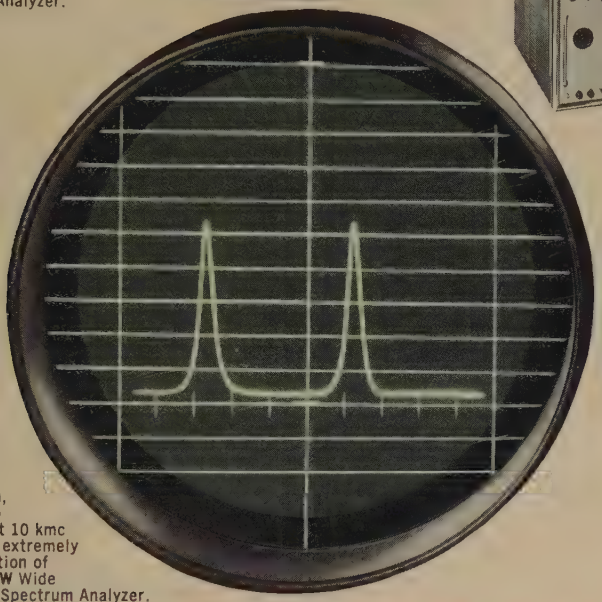


Visual display instantly shows distribution of microwave energy around carrier frequency. **Model TSA** Spectrum Analyzer.

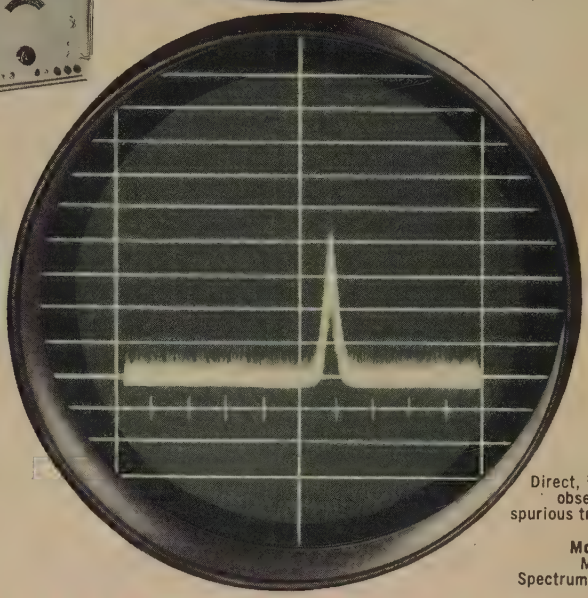


Pulsed signal displayed as a function of time. **Model TSA-S** Combination Synchroscope-Spectrum Analyzer.





Rapid signal comparison, accurate to .00025% at 10 kmc because of extremely fine resolution of **Model TSA-W** Wide Dispersion Spectrum Analyzer.



Direct, immediate observation of spurious transmitter radiation. **Model SA-84** Multi-Band Spectrum Analyzer.

VISUAL MICROWAVE ANALYSIS

4 microwave analyzers cover every application, 10–44,000 mc

MODEL TSA SPECTRUM ANALYZER — 25 kc resolution, 400 kc to 25 mc dispersion. 5 sensitive tuning units.

MODEL TSA-S COMBINATION SYNCHROSCOPE-SPECTRUM ANALYZER — 5 kc to 5 mc adjustable bandwidth, 400 kc to 25 mc dispersion. Time and frequency display. 5 sensitive tuning units.

MODEL TSA-W VERY WIDE DISPERSION SPECTRUM ANALYZER — 7 kc and 50 kc resolution, 100 kc to 70 mc dispersion. Logarithmic amplitude display. 5 sensitive tuning units.

MODEL SA-84 MULTI-BAND SPECTRUM ANALYZER — 10 to 40,880 mc in a single unit.

Polarad spectrum analyzers are basic "scopes" for all microwave work. They display instantaneously such parameters as attenuation, insertion loss and gain, bandwidth characteristics, SWR, frequency, power, etc. In addition they detect and display modulator and transmitter malfunctions such as double moding, misfiring, pushing and pulling by a magnetron, and frequency drift.

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MAIL THIS CARD for specifications. Ask your nearest Polarad representative (in the Yellow Pages) for a copy of "Notes on Microwave Measurements"

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Please send me information on

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☐ Microwave Spectrum Analyzers
☐ Model R Receiver (see reverse side of this page)

My application is:_____

Name_____

Title_____ Dept._____

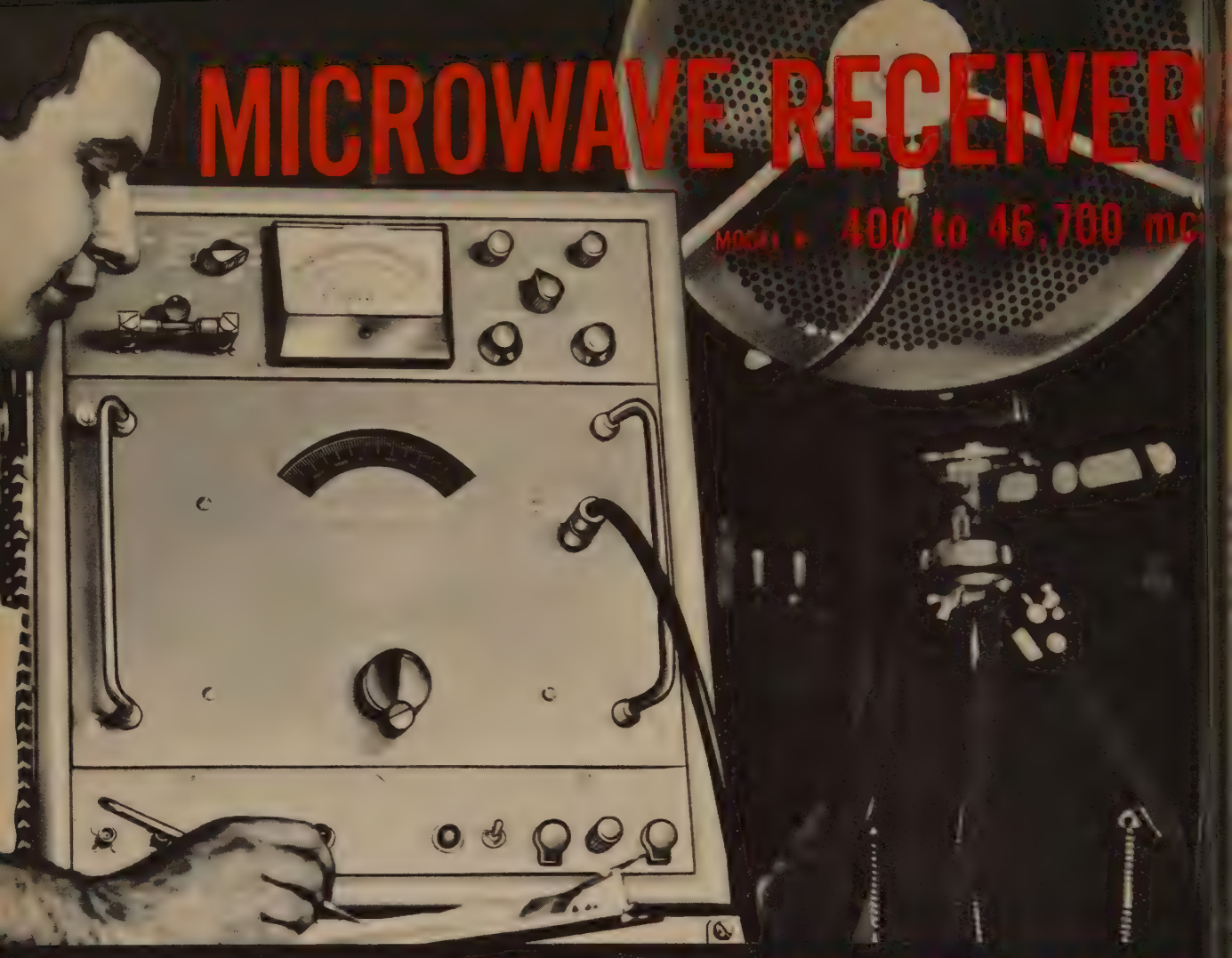
Company_____

Address_____

City_____ Zone_____ State_____

MICROWAVE RECEIVER

MODEL R 400 to 46,700 mc



A MULTI-PURPOSE PRECISION TEST INSTRUMENT

DETECTS AND MEASURES:

- Antenna patterns
- Field intensity
- R-F power
- R-F noise figure
- Leakage and interference
- Filter characteristics
- Bandwidth of microwave cavities
- Attenuation
- Insertion gain and loss
- Relative power differences between fundamental signal and harmonics

POLARAD

POWER RELIABILITY

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Now — one basic instrument serves for general communications as well as for detection and complete quantitative analysis of microwave energy.

Polarad Model R Receiver accepts all microwave signals: AM, FM, CW, MCW and pulse. Power and frequency are read directly on front panel indicators.

It permits all standard forms of signal monitoring: special output jacks for audio and video; trigger output to reproduce pulse width and repetition rate; recorder output to transcribe signals through commercial recording equipment.

Model R is simple to operate, extremely sensitive, highly accurate, and is designed for quick, easy inspection and servicing. It provides AFC, AGC, and continuous UNI-DIAL tuning. Eight interchangeable tuning units cover the entire frequency range.

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(*Continued from page 56*)

manufactures liquid helium research dewars and related apparatus for cryogenics, and the book relates the application of Hofman equipment in various fields of low temperature studies. The book is liberally illustrated with photos of installations at the National Bureau of Standards, U. S. Naval Research Laboratories, Bell Telephone Laboratories, etc. Engineering drawings and performance curves of Hofman's wide line of dewars and containers are included. Elaborate technical data on liquid helium, hydrogen and nitrogen is presented. Copies are available upon request.

CIRCLE READER SERVICE CARD 108

• • •

RELAY DEFINITIONS AND TESTING PROCEDURES

These procedures are outlined in a seventy page progress report by the National Association of Relay Manufacturers' Technical Committees on, (a) Dry Circuits (low energy switching), (b) Measurement of Electrical Characteristics, (c) Contact Life Testing, (d) Environmental Testing including Temperature, Humidity, Altitude and Corrosion, (e) Vibration Testing, (f) Shock, Acceleration and Tumbling.

The report presents suggested definitions and test procedures, discusses test equipment and precautions, outlines work yet to be done and solicits comments and suggestions on work accomplished to date.

Copy of the report is available on request.

CIRCLE READER SERVICE CARD 109

SYLVANIA ANNOUNCES NEW CATALOG ON REFLEX KLYSTRONS AND ROCKET PLANAR TRIODES

A new four-page catalog on reflex klystrons and Rocket planar triodes has been made available by Sylvania Electric Products Inc.

Principal electrical characteristics for 22 klystron types and nine planar triodes are listed. Tube applications include microwave communication transmitters and receivers, test equipment, beacons and missiles, according to Thomas D. Fuller, marketing manager of Sylvania's Special Tube Operations.

Frequency coverage of the klystron line is 500 to 7500 megacycles, with CW output power ranging from 20 milliwatts to two watts. The klystrons are divided into five basic outline styles, each illustrated by a proportionately scaled photograph.

Rocket planar triodes are designed for oscillator or amplifier applications, and are available in either pulsed or CW versions with frequency coverage from 500 to 3300 megacycles. The catalog lists amplification factors as high as 90, and peak power outputs to 200 watts for oscillator operation.

The tubes shown were developed and are manufactured at Special Tube Operations facilities in Mountain View, Calif. and Williamsport, Pa.

Copies of the new catalog can be obtained upon request.

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Westinghouse *invites*

Senior Scientists and Engineers to explore opportunities in the NEW . . .

Microwave Research and Development LABORATORY

Accelerated growth in activity at the Electronic Tube Division in Elmira, N.Y. has recently required the establishment of a new Microwave Research and Development Laboratory. This has created several outstanding positions for experienced engineers and scientists. A rewarding future will be assured for men who wish to pioneer in uncharted areas of the microwave field. Those meeting the qualifications will find challenging assignments in association with the high caliber scientists and engineers at Westinghouse. Academic association with Cornell University is encouraged.

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or call collect Elmira REgent 9-3611

Westinghouse
ELECTRONIC TUBE DIVISION ELMIRA, NEW YORK

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General Communication Company is now producing PCS-1A Pulse Power Calibrator for industry and the National Defense.

Model PCS-1A

Frequency Range:
925 mcs to 1225 mcs

Power Level Range:
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Accuracy: 0.5 db

Accuracy unprecedented for R.F. pulse measuring equipment — in a fraction of the time with corresponding hourly rate savings.

The equipment does not need another primary standard to prove the accuracy of its calibration. No additional components having unknown errors required. The answer obtained is final.

Similar equipment for other frequencies under development. We welcome your inquiries on this and other developments in the microwave field.

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CIRCLE READER SERVICE CARD 37

Engineers and Physicists:

radar
microwave
antennas
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GPL announces junior, senior and intermediate openings in the design and development of circuitry, systems or components, for the latest in airborne missile guidance and Doppler techniques, as well as radio communications. Several of these positions require supervisory potential and carry commensurate salaries.

EE or Physics degree is desired plus some experience with either circuit design and analysis, or antenna and other microwave component design.

Engineers and Physicists who wish to arrange for a personal discussion of their future at GPL should call (collect) ROgers 9-5000, write or submit their resumes. Inquiries will be held in strictest confidence and answered promptly.

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NARDA MICROWAVE CORPORATION
Mineola, New York

THE IMAGE OF A COMPANY IS very often the reflection of one man.

That of The Narda Microwave Corporation, however, is the reflection of four men: the four founders—Dr. John McGregor, Bill Bourke, Stu Casper and Jim McFarland.

From the beginning the four have worked as a team—a nicely-balanced team, too, with each man contributing certain unique talents and experience which have served to supplement those of the other three.

All four are still active in the firm and provide its top management (see page 63).

Each of the four was an experienced microwave engineer in his own right when they decided to join forces (in February, 1953), and launch their own venture.

The happy blending of these four personalities in large part accounts for the company's steady growth. The combination of skills has provided a solid foundation on which to build a smoothly-functioning, continuously expanding organization.

The company's first products were several X-band instruments, a wide-range frequency meter, and several kinds of attenuators and terminations. The four founders divided up among themselves the burden of design, testing, selling, and sweeping out the plant. Manufacturing was initially sub-contracted to the machine shop on Herricks Road in Mineola from whom the four associates rented a small back room.

Initial sales to Kollsman Instrument Company, the Signal Corps, the Bureau of Standards, and Maxson Corporation sustained the infant company during its first few months, and by the end of the summer of 1953 the group had perfected its first "sophisticated" product, the Model 802 Frequency Meter which covered S to X bands—a design which, in greatly improved form, is still a popular catalog item. That fall also saw the design of a High Power Impedance Meter, a fairly expensive item, and the sale of one of these meters, in October, set a new all-time record sales figure. Bell Laboratories then came through with an order for five of these, all of which were delivered in November.

A development contract from the Navy's Bureau of Ships covering the investigation of the degree of protection offered by various finishes to waveguides exposed to salt spray, marked a new direction for the group.

By this time, also, the little company had relocated in its own plant at 66 Main Street, Mineola, and was quite proud of its 1600 sq. ft. In December, 1953, its first frequency meters started coming off the production line, destined for such customers as Wheeler Laboratories, Trans-American Precision Gear, Aircraft Armaments, Gabriel Laboratories, Bell Labs, and the University of California.

Just about every dollar of revenue was plowed back into the company by its four executives—none of whom drew any salary from August to the beginning of De-

In this spacious engineering lab, Narda's further contributions to microwave engineering are now being worked on. Group standing in center guide the company's product-development program. Left to right: Leonard I. Kent, chief microwave engineer; Stuart D. Casper, vice-president in charge of engineering; and James E. McFarland, vice-president in charge of manufacturing.

Box Score

NAME: The Narda Microwave Corporation.

LOCATION: 118-160 Herricks Road, Mineola, L.I., New York.

PRODUCTS: Microwave and UHF test equipment and components covering the frequency range from 20 to 90,000 mc, including:

Waveguide and coaxial attenuators; Bolometers and thermistors; Waveguide and coaxial detector mounts, crystal mixers and harmonic mixers; High directivity directional couplers; Coaxial hybrid junctions and couplers; Frequency meters; Low pass filters; Harmonic generators; Impedance meters (waveguide and coaxial), r-f probes, standard reflections; VSWR amplifiers and microwave power meters; Klystron power supplies; Radar performance checkers, echo boxes, tuned pre-amplifiers; Precision fixed and sliding coaxial and waveguide terminations and high power loads; Tuneable waveguide shorts, double stub and E-H tuners; Tube mounts, waveguide-to-coaxial adapters, straight waveguide sections, flange adapters, stands and clamps, tees, twists, bends.

High Power Electronics Division: Microwave modulators.

HIGHLIGHTS: Only six-and-a-half years old, Narda Microwave has grown to a position as one of the leaders in this highly-specialized field by developing a very complete range of both waveguide and coaxial equipment, in which a high degree of creative engineering has been applied, strongly oriented toward fulfilling the needs of the systems-builders who will put the equipment to use.

STATISTICS: Narda's main plant and laboratory occupy four buildings strung out along one block of Herricks Road in Mineola with a total floor space of about 20,000 sq. ft. In the latest fiscal year, ended June 30, 1959, microwave sales exceeded the $1.5 million mark, a 50% increase over the previous year. In the first quarter of the current fiscal year orders have been received at a rate that indicates a $2.5 million total for the year. This does not include estimated sales for the newly-established High Power Electronics Division.

Operations have resulted in a net profit in each of the past four years. Five cash dividends have been paid, plus six pro-rata distributions of the stock of Narda Ultrasonics Corporation, a subsidiary now 38% owned.

The company is publicly-owned with about 1500 shareholders residing in more than 30 states and several foreign countries. As of June 30, 1959, there were 600,000 shares outstanding. The company at this writing employs about 200 people, more than half of whom are also stockholders.

cember in that first year. Much of the money went for additional test equipment — so that every product shipped could be certified as having completely met its performance claims.

At the same time, the group worked hard on the development of bolometers, which were announced to the world in January, 1954.

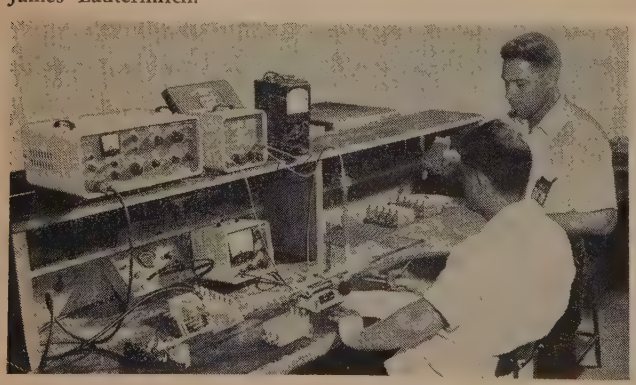
This was Narda's first bold bid for recognition as a company that was not only willing but able to contribute to the advancement of the art.

Conditions like these separate "the men from the boy And, under conditions like these, Narda now stands out.

By the late spring of 1955, the company's range products had grown to such an extent that the 16 square feet on Main Street was completely inadequa So, in July, Narda moved to 160 Herricks Road in Mi eola. And, in the months since then it has added one buil ing after another in the same block until it now occupi four, strung out like beads on a chain.

(*Story continued on page 64*)

Coaxial couplers are carefully calibrated after production, and the calibrations are stamped individually and directly on the scale attached to each coupler. Les Lipset, Chief Test Engineer of Narda's production test department, spot-checks the work of James Lautermilch.



Well-filled milling machine department (only partly shown this photograph) turns out components in quantity for Narda products. Center foreground: Thomas Duff, milling machi leadman, reviews the many close tolerances of parts to be ma on a new three-spindle tracer-controlled milling machine wi Wallace Hassenfratz. Other operators in foreground are, l to right, Don Wilson and Thomas Ford.

Narda's Management

DR. JOHN C. McGREGOR, CHAIRMAN OF THE BOARD OF DIRECTORS, age 40, is a graduate physicist of Carnegie Institute of Technology and is also a Doctor of Jurisprudence. Prior to the formation of Narda, Dr. McGregor had been engaged as a physicist with the Gulf Research and Development Corporation and the United States Navy; and as a microwave development engineer and later in patent and contract activities with the Sperry Corporation. Dr. McGregor, along with the other three officers, founded the Narda Microwave Corporation and has served since that time as its President and Chairman of the Board. He is a senior member of the Institute of Radio Engineers, and a member of the Institute of Aeronautical Science.

WILLIAM A. BOURKE, PRESIDENT, age 35, was graduated by the Carnegie Institute of Technology as an electrical engineer and was subsequently employed by the Sperry Corporation as a microwave project engineer engaged in the design and development of radar field test equipment for the Armed Services, microwave components, and commercial laboratory microwave instruments including a primary standard of attenuation. In the early years of Narda Mr. Bourke participated in the company's engineering effort and was responsible for several of the company's products. Subsequently he engaged in formulating and administering Narda's sales program, and more recently has been responsible for over-all company administration. He is a senior member of the IRE and of the PGMTT of the IRE. His other organizations include the AIEE, *Eta Kappa Nu, Phi Kappa Phi, Tau Beta Pi,* and *Omicron Delta Kappa.*

Stuart Casper William Bourke John McGregor James McFarland

STUART D. CASPER, VICE-PRESIDENT IN CHARGE OF ENGINEERING, received the degree of Master of Electrical Engineering from Rensselaer Polytechnic Institute and for a period taught electrical engineering there. He has an extensive background in the field of microwave and UHF test equipment including experience in the research laboratories at Sperry Corporation.

Since joining in the formation of Narda, Mr. Casper has designed many of Narda's products and now supervises a steadily growing force of product-development and testing engineers.

Mr. Casper is a senior member of the Institute of Radio Engineers and of its Professional Groups on Instrumentation, Electron Devices, and Microwave Theory and Techniques. He is presently also membership chairman of the Long Island Section of IRE, and an associate member of *Sigma Xi.*

JAMES E. McFARLAND, VICE-PRESIDENT IN CHARGE OF MANUFACTURING, directs the company's manufacturing operations but also continues to be active in the firm's product-development work. He was graduated from the University of South Carolina as an electrical engineer. He worked for a time in broadcasting as an engineer, and then joined the microwave laboratories of Sperry Corporation as a project engineer.

At Narda, Jim has designed microwave antennas for several frequency ranges and has also been responsible for the development of the Narda line of coaxial directional couplers and terminations (to which he has contributed a number of innovations), as well as collaborating on the development of many other products.

Mr. McFarland is a senior member of the Institute of Radio Engineers.

In June, 1957, Narda acquired and absorbed Kama Instrument Corporation, also of Mineola, and thereby acquired the present manufacturing superintendent, Don Robertson. A month later, Leonard Kent joined the firm as Chief Microwave Engineer.

By this time, too, the company's growth had reached the point where it was beyond the ability of the four founders to finance. That summer, therefore, Narda made its first public stock offering. (Previously, stock had been offered only to key employees and to one or two of Narda's sales representatives.) 90,000 shares were sold at $3 a share, and the issue was an outstanding success.

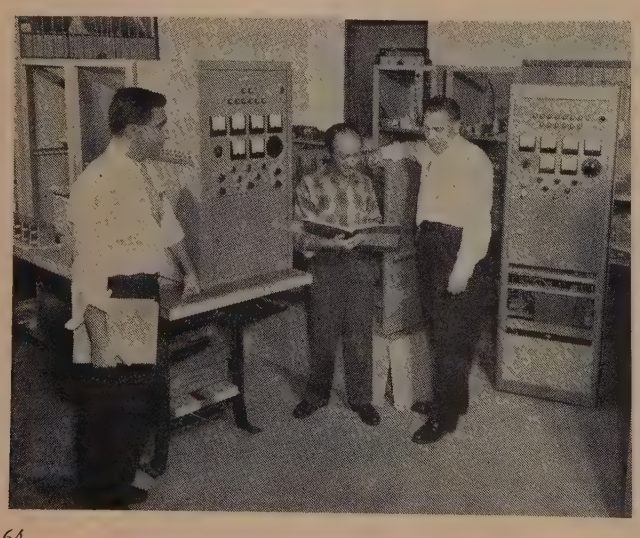
In the fall of 1957, Narda established a new subsidiary, The Narda Ultrasonics Corporation, to venture into the promising field of ultrasonic devices for cleaning and other purposes. This subsidiary is now flourishing in its own right in a modern plant in Westbury, L.I., employing about 125 people and showing a very attractive sales record.

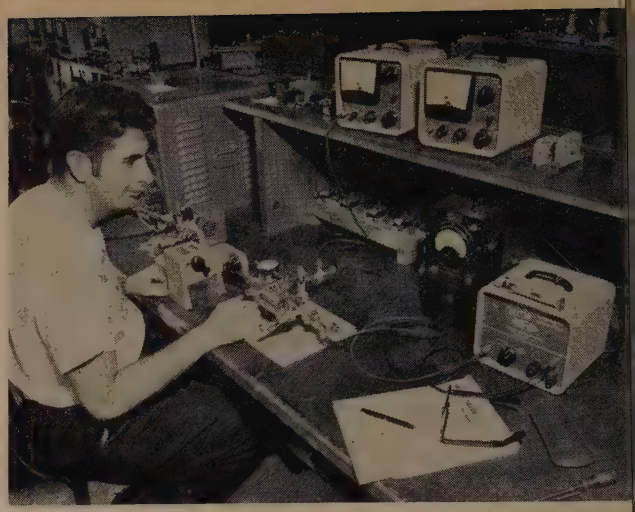
Products

In developing crystal-shaped bolometers, and later thermistors, both of which are essential products for microwave measurements, Narda tackled an area where many other microwave companies had feared to tread. By dint of considerable engineering effort, Narda came up, eventually, with a complete line of these highly important elements which possessed the dependability and adaptability that the industry wanted. Narda's success with these products helped give the company a reputation that has earned them consideration in many other situations.

In all of its product-development efforts, Narda has always sought to build into its products a little bit more in performance, a number of additional or unique features, in order to come up with an item that is distinctive and offers some extra convenience or versatility. And these efforts do not stop with the initial introduction of the item — its products are constantly being improved, so that what was *good* to start with has later been discarded for the better and what is offered at any moment is truly the *be* the present state-of-the-art can produce.

New microwave modulator is explained to Leonard I. Kent, chief microwave engineer (at right) by Carl Roechlein (center) as Howard S. Bertan, manager of Narda's recently-established High Power Electronics Division (left), looks on. Prototype of a new, higher-powered modulator, just completed, stands at right of Mr. Kent.





Performance of a millimeter waveguide set-up is tested Nick Andriotty.

This objective has helped Narda's sales — but the Com pany feels it has helped the microwave industry, too. Fo example, one of Narda's newer products, the fully tran istorized Model 440 power meter is a unit that is not on portable, but offers complete freedom from line volta fluctuations and includes a self-contained battery charg and indicator to show state of battery charge.

Another comparable pioneering development was th introduction of a complete line of directional coaxi couplers. With these and other products developed sin that time Narda was applying another policy which stam it as exceptional — its design-efforts have been strong customer-oriented, that is, directed primarily towards u derstanding and fulfilling the requirements of the use

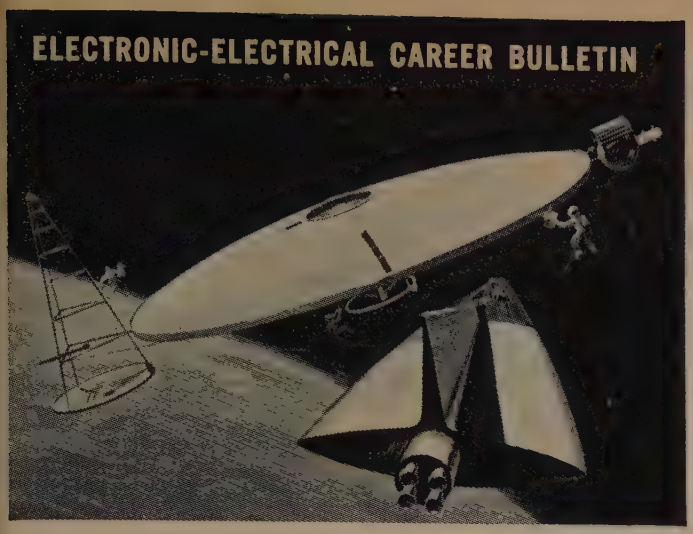
In the microwave industry, no single product can gi its supplier a reputation for reliability. Its major cu tomers — the systems designers like General Electri Hughes, Raytheon, Boeing, Republic Aviation, Marti Sylvania Electric, Convair, Westinghouse—are often ther selves designers of individual components.

But when they can find a supplier with a fairly comple range of products — which Narda was rapidly developin in both the waveguide and coaxial fields — all of the well engineered, backed by precision manufacturing met ods and facilities that assure dependable delivery and r liable performance — they will tend to buy more a more from that supplier.

Attaining that position of confidence — and retainir it — calls for both a high degree of creativity in desig and a "Rock-of-Gibraltar" integrity in the matter of pe formance claims.

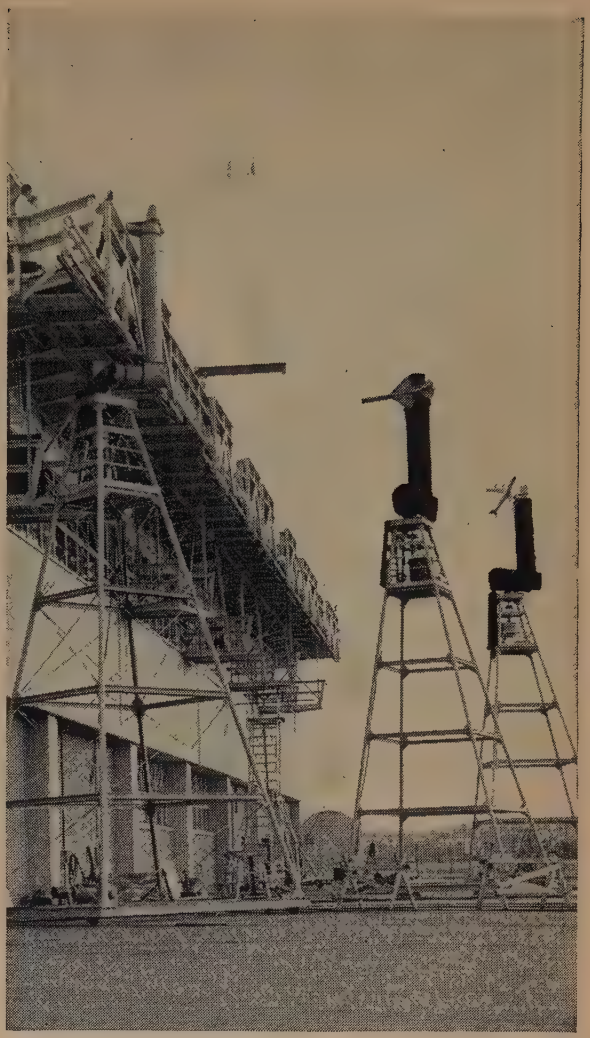
That is the objective which Narda has assiduous sought — and in six-and-a-half years the company h marched steadily forward until it now occupies such position among the leaders of the industry.

Under Leonard Kent's direction, the microwave pro ucts have been expanded to cover all varieties of wavegui equipment up to 90,000 mc and coaxial equipment fr 20 to 12,400 mc. In addition extensive development a tivities have been carried out in areas such as ridg waveguide operating over 2.4:1 and 3.6:1 frequency ban Electronic accessories including Klystron power suppl

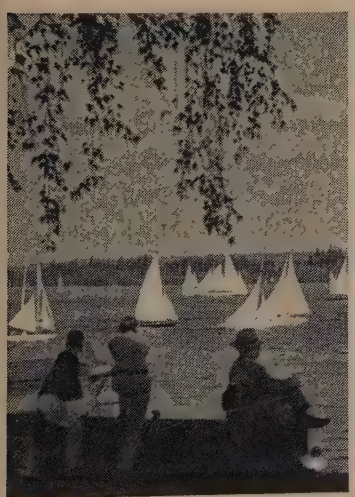


MARS VEHICLE. Drawing, based on Boeing study, of space vehicle designed for launching from orbiting platform for reconnaissance flight to Mars and return. Lunar, orbital and interplanetary system studies, and expanding programs such as the advanced Minuteman solid-propellant ICBM, are typical of challenging, long-range assignments Boeing offers electronic-electrical engineers.

DARK TUNNEL. View in 100-foot dark tunnel, part of extensive Boeing infrared research and development facilities. Boeing investigations include use of infrared, visible and ultra-violet techniques for use in communication, navigation, detection and guidance at altitudes above tropopause. IR systems, inertial navigation, electrical power systems for satellites, shockwave radiation and refraction and irdome heating are other areas of assignments open at Boeing.



ANTENNA PATTERN RANGE, with movable towers capable of handling models up to 1000 pounds. Boeing has openings in ECM antenna development, and in gas, solid and liquid dielectric research, as well as large-aperture antennas for ASMs, orbital vehicles and airborne warning systems. Other openings are available in instrumentation, missile guidance and control.



SEATTLE area, boating capital of U.S., offers world-famous recreational facilities. Fresh and salt water boating and fishing are only one hour from dramatic snow-capped mountains renowned for six-months-a-year skiing. Mild year-round climate. Excellent schools and universities, cultural activities, modern housing and shopping centers. Wonderful Western living for the whole family!

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and transistorized VSWR Amplifiers and power meters are among the most popular products. The newest product group, high power microwave modulators, are already gaining wide recognition.

Future

Its extensive investment in product research and development is a good indication that Narda is not content to leave its future growth to chance. And, being confident that it *will* grow, it is taking steps *now* to build an even stronger management team in readiness for that future growth.

Some firms accomplish this by "importing" talent from outside. Narda prefers to train its own men to become capable of assuming greater responsibilities.

The method Narda is using is not unique — but it is not often encountered in firms of this size. It consists, quite simply, of conducting the company's own "school" in techniques of management. Since June of this year, regular classes have been held each Tuesday morning, during business hours. There are two class-groups, one meeting from 8 to 9 a.m., the other from 9 to 10 a.m. Each class-group is made up of about 13, mingling together all levels of supervision from all departments.

The case-study method, originated by Harvard Business School, is followed. Function of the course is not in any way indoctrination in company policies or even education in microwave or electronic science — it is devoted solely to training the participants broadly in the most effective methods of modern business management. In the main, the discussions are led by Bill Bourke, president, with an c casional "assist" from Dean Francis K. Ballaine of Adel College, who is also head of the college's Advanced M agement Development Program.

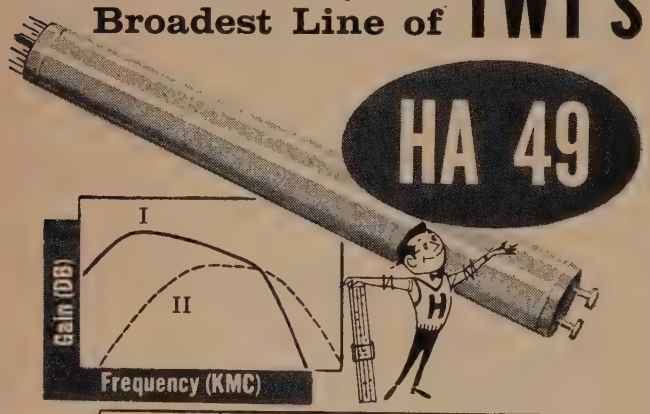
A secondary and unexpected benefit from this cou is that it provides an additional channel of communi tion between top management and the next echelo Supervisors with whom Bill Bourke might not happ to have direct contact for weeks at a time, are broug face-to-face with him every week. But this is stric a side-value and the course is in no way allowed to dup cate the function of a staff meeting. Narda's own proble are introduced into the course only where they are relev

Philosophy

An attribute of Narda Microwave — which has chara terized the company from its beginning — is its co servative approach to performance claims and its avoi ance of spectacular promotional methods.

Narda has not tried to match the production-volume a resulting lower-prices of the mass-producer of relative simple microwave components. Instead, the company h deliberately chosen the harder road — which offered slower rate of growth, perhaps, but a steadier and sur one. As a result, Narda will be found in the picture mo and more today when a systems-builder demands pro ucts with very close tolerances, a higher degree of co plexity, a greater range of performance, and the utmo reliability.

The Industry's Broadest Line of TWT's



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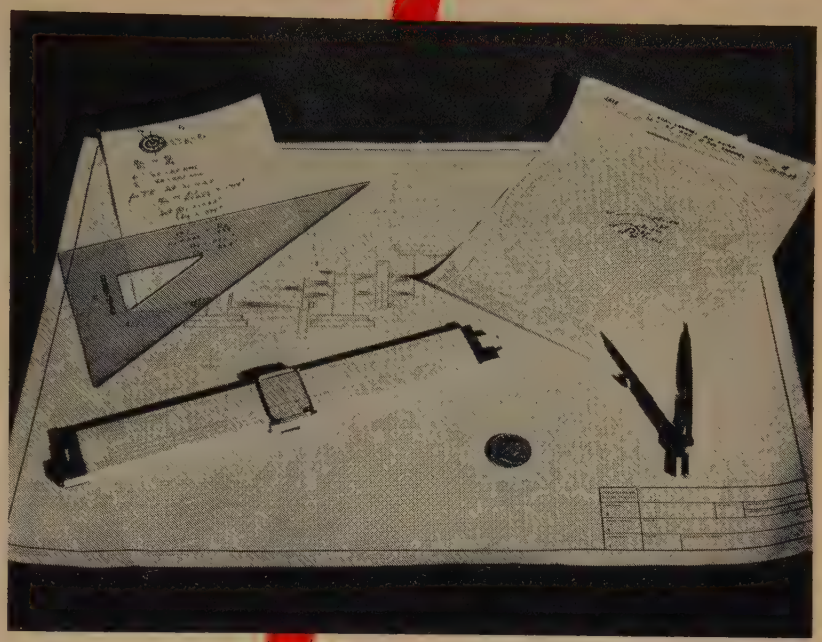

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the microwave journal

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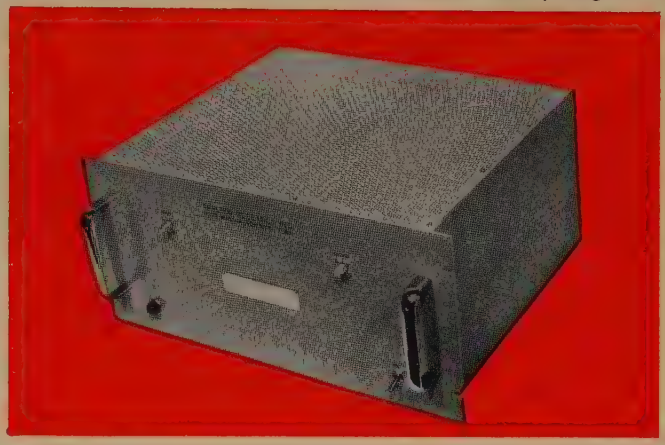

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nating drain of battery power when the nstrument is not in use. The battery cir-uit can be checked whenever desired by neans of a spring-loaded push-to-test witch on the front panel. Operating ower is obtained from easily replaceable nercury cells having an operating life n excess of 100 hours.

Frequency range covered by the Densi-meter is 200 to 10,000 mc in five steps. Density range is 0-20 mw/cm², with ac-uracy and sensitivity both ± 1 db. The nstrument, without antenna, measures nly 5¾ by 2⅞ by 2 inches. Depending pon the antenna in use, weight is 1.5 to pounds.

Engineers of Radar Measurement Corp-ration have stated that the Model 1200 Densiometer was developed to meet the eeds of laboratories, plants and oper-ting installations for an accurate yet imple means for safeguarding personnel gainst accidental exposure to damaging adiation. Medical investigation, they tate, has shown that exposure to high evels of short wave radiation can cause evere physical damage to internal organs nd eyes. Moreover the effects of such xposure are often gradual and cumula-ive, so that hazards are especially great or personnel whose work exposes them o such radiation over long periods of ime.

Pointing out that previously available quipment was costly and so complex hat it could only be used properly by echnically trained personnel, the com-any is offering the Model 1200 to radar nanufacturers and operators as a low ost protective device that can be used or routine monitoring, spot checks and eriodic safety surveys, without the need or special training or the use of complex nstrument installations.

Complete descriptive and technical data n the Model 1200 Densiometer is avail-ble upon request.

CIRCLE READER SERVICE CARD 111

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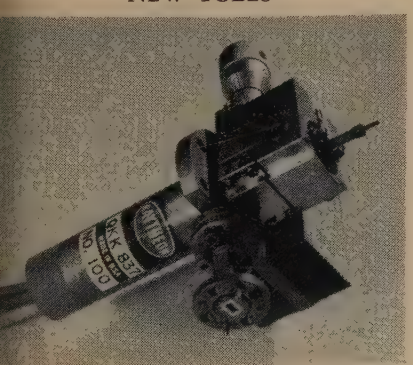
RAYTHEON ANNOUNCES TWO NEW TUBES



Raytheon types QKK837 and QKK838 re mechanically tuned velocity varia-on oscillators designed for operation the 67,000 to 73,000 megacycle range ith minimum output of 10 milliwatts. he RF output is through waveguide aled by a mica window. The output ange mates with a standard UG385/U ver-flange.

CIRCLE READER SERVICE CARD 112

220-400 MC RANGE COVERED BY NEW MODEL MA-1-350 PARAMETRIC AMPLIFIER

Adding to the line of Microwave Associates parametric amplifiers, Model MA-1-350 tunes from 220-400 MC. The unit's specifications feature a noise figure below 2 db for up to 20 db gain and approximately ¼% bandwidth. Typically, pump power of 100 milliwatts is required at a pump frequency of approximately 4 times the signal frequency. The input and output impedance matches a 50 ohm line. In the non-amplifying condition, insertion loss of the cavity is approximately 0.2 db. Type N fittings are provided for injection of RF pump power, and connection of signal input and output to receiver.

Micrometer tuning is used to establish idler resonance and a tunable quarterwave stub is used to obtain cavity resonance at signal frequency.

The MA-1-350 is recommended for use in laboratory experiments or in breadboard receiver design work together with existing receiving equipment.

The MA-1-350 is supplied with two (2) suitable Varactor diodes and is also available with complete auxiliary equipment including pump oscillator, pump power supply, and interconnecting cables.

Overall cavity dimensions are 10⅞" high by 4" diameter. Metal conducting surfaces are silver plated and external surfaces are painted with blue-grey enamel.

The MA-1-350 is one of three amplifiers of this type for the 100 to 500 MC range. Its salient features include:

(a) Extremely low noise figure in the 0-2 db range depending upon the sensitivity of the receiver with which it is used.

(b) Wide dynamic range.

(c) Fail-safe receiver performance (if pump fails noise figure of the receiver is retained).

(d) Immediate recovery from temporary overload and resistance to damage from temporary overload.

(e) The Varactor diode working element requires no D.C. voltages.

(f) Phase coherence is retained on all input signals.

(g) Significant reduction of cross modulation is obtained as compared to that possible with crystal diode mixers or vacuum tube preamplifiers.

CIRCLE READER SERVICE CARD 113

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NEON NOISE SOURCES

Kay Electric Company, Pine Brook, New Jersey, has added a new group of Neon noise sources to their present extensive line of noise generators. Designed to operate in the range from 1,120 mc to 26,500 mc, the new Neon tubes provide 18 db of excess noise, and are physically interchangeable, in most cases, with present models of the Kay Microwave Mega-Nodes, using the Argon tube. Power supplies designed to operate these Neon sources are available from stock.

Addition of the new Neon sources completes an already versatile line of

noise generators using temperature regulated diodes, gas discharge tubes of Argon, Neon and Mercury, and a new noise generator utilizing a resistive element at 2000°K. Availability of these new Neon noise sources is in the same category as other units produced by the company.

CIRCLE READER SERVICE CARD 114

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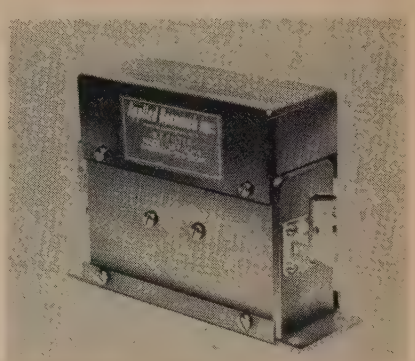
BANDPASS FILTERS FEATURE HIGH PERFORMANCE AND RELIABILITY, SMALL SIZE

Applied Research Inc., Port Washington, N.Y., announces the availability of a family of bandpass filters (Model HFF (C) —) operating in the frequency range 300 to 1000 mcps. The units feature maximum reliability and minimum size, and are designed and packaged to operate under military environmental conditions. The filters operate from a 50-ohm and into a 50-ohm impedance and have a skirt selectivity ratio of less than three to one. They are aligned to obey the Butterworth condition, and have a very low insertion loss.

Typical of these filters is a unit for operation at 332 mcps with 3 db bandwidth of 24 mcps. With this center frequency, weight of the filter is 20 ounces. Dimensions of the case are 5 1/8" long



by 1 11/16" wide by 3¼" high. Packaging can be tailored to customer requirements.

Further information and characteristics are available upon request.

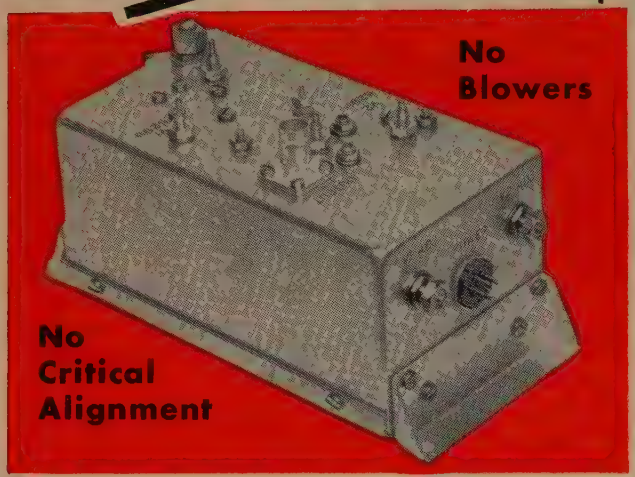
CIRCLE READER SERVICE CARD 115

Applied Research inc.

UHF AMPLIFIERS

LOW NOISE FIGURE

LESS THAN 1.5 db at 108 mcps
2.25 db at 235 mcps



Amplifier Model UH-2(A)S operates in the frequency range 60 to 300 mcps. This amplifier is a two tube unit with broadband response, high gain, and low noise figure. The unit requires no additional air cooling supply, as natural ventilation is used. A power supply is available, with complete equipment assembled in a chassis suitable for mounting in a 19-inch rack. The amplifier is available without power supply for users who have local power available. Small size and low weight are featured in the rugged chassis. No tubes are exposed to external injury. The chassis is silver plated with gold flash finish.

Specifications of two representative units are given below.

SPECIFICATIONS — MODEL UH-2(A)S AMPLIFIERS

Center frequency:	108 mcps	235 mcps
Bandwidth:	4-10 mcps	4-10 mcps
Gain:	25 db	25 db
Average noise figure:	1.5 db	2.25 db
Input impedance:	50 ohms	
Output impedance:	50 ohms	
Connectors: input	Type BNC	
output	Type BNC	
power	Miniature hexagonal	
Power requirements*:	150 VDC at 20 MA, 6.3 VAC at 0.7 A	
Dimensions*:	6¾" L x 3½" W x 3½" H	
Weight*:	2⅞ lbs.	
Finish*:	Silver plated with gold flash	

*Amplifier without power supply.

For additional information write

Applied Research inc.

76 South Bayles Avenue, Port Washington, N. Y.

74 CIRCLE READER SERVICE CARD 41

MICROWAVE ENGINEERING GROUP LEADER

We are seeking a Senior Microwave Engineer to assume responsibility for the design and development of microwave systems and components for our advanced airborne navigational systems.

He will need at least a BS in EE or Physics, with advanced degree desirable, plus several years of microwave experience. This position provides an excellent opportunity to expand a microwave background into systems design areas.

He will join a youthful, vigorous organization with 2000 employees whose growing record of achievements covers many areas. His salary will take full account of his qualifications and keep pace with his accomplishments. He will receive full tuition refund for advanced study he may undertake.

We will welcome the opportunity for a full discussion of the position, the company, the salary.

Intermediate-level openings in Microwave Engineering are also available

Please contact Mr. Harold Goldberg, Manager, Receiver-Transmitter Section, 75 Pitts Street, Boston 14, Mass. Tel. RIchmond 2-3200.

LABORATORY FOR ELECTRONI

SENIOR ENGINEERS

We have immediate openings for qualified applicants in the following fields of engineering. Applicants must have B.S. degree or higher with a minimum of three (3) years experience.

DESIGN:

1. Design and develop remote controlled disconnect (umbilical or explosive breakaway), bellows actuator, or printed circuit connectors. ME degree desired.
2. Design and package electrical ignition systems equipment. Interest in development of igniters for liquid and solid fuel. EE degree desired.

RESEARCH:

1. Analysis and coordination of electro-mechanical ignition systems, involving utilization of semiconductors, tubes, gaps. Analyze phenomena of ignition of solid fuel.

Please send resume giving full particulars to:

Scintilla Division
BENDIX AVIATION CORPORATION
Sidney, New York

ARE YOUR TALENTS BEING RECOGNIZED?

Hughes Fullerton's unique, new Professional Capabilities Register insures recognition of all your abilities

Most engineers have had to face an unpleasant fact. Often an employer will hire from outside to fill a supervisory position. Entirely qualified men "inside" are passed over. The problem is generally one of communication. The employer simply does not have adequate knowledge of his employees' abilities and promise.

We believe our new Professional Capabilities Register is the most carefully designed comprehensive plan ever devised to meet this critical problem. We expect it to pay many dividends in maximum utilization of our manpower resources. It reflects the complete engineering-orientation of this fastest-growing Hughes activity. (From 800 to nearly 6,000 people since 1957. Planned, *scheduled* growth.)

The Register makes instantly available a complete record of every individual's abilities, interests and accomplishments. Previously hidden talents can now be put to use. Often these can mean the difference when reassignments or promotions are being made. Your potentials become a very real resource of Hughes-Fullerton R & D Staff.

Areas covered in the Register range from language skills through patents to books and articles published. It includes teaching experience, professional affiliations. All data is kept up-to-date and handled by automatic data processing equipment for utmost efficiency.

Hughes-Fullerton's philosophy of giving precedence to the needs of engineers has worked well. Hughes-Fullerton was first with three-dimension radar... a major breakthrough in the state of the art. Other vital areas of interest include advanced data processing and electronic display systems.

You should investigate Hughes-Fullerton. Our mushrooming growth makes openings available at several experience levels for a variety of engineering specialties. Please telephone (collect) or write Mr. B. P. Ramstack, Director of Professional Placement at Hughes Aircraft Company, Hughes-Fullerton Research & Development, Fullerton, California.

Creating a new world with ELECTRONICS

HUGHES

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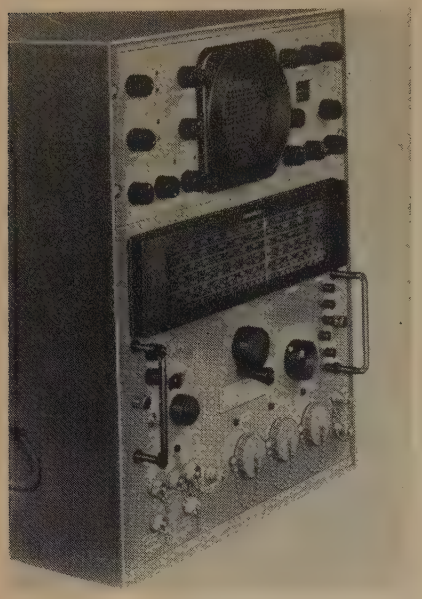
FULLERTON RESEARCH & DEVELOPMENT
FULLERTON, CALIF. PHONE TROJAN 1-4080

PANORAMIC'S SPA-4 SPECTRUM ANALYZER



Exceptional usable sensitivity—exceeding 100 dbm — unusually stable, accurate and versatile; Panoramic's SPA-4 Spectrum Analyzer features 0-70 mc and 0-5 mc independent frequency dispersion ranges, with negligible internal frequency modulation; a variable 1-80 kc I.F. bandwidth; precisely calibrated log, linear and power amplitude scales; a single tuning head with a 10 mc to 44 kmc frequency range; and a self-contained marker oscillator for accurately measuring small frequency differences.

Manufactured by Panoramic Radio Products, Inc., Mount Vernon, N.Y.

The SPA-4's exclusive eight-button frequency range selector automatically couples the selected band's proper mixer and oscillator, and at the same time illuminates both the slide rule calibrated dial of the 10 mc to 44 kmc range single tuning head and the applicable input connector.

There are two independent, continuously variable, frequency dispersion ranges — 0 to 70 mc sweep width, designed for wide band investigations; and 0 to 5 mc sweep width for extremely stable narrow band analysis. Negligible internal frequency modulation permits extremely narrow band analysis free of FM problems. The SPA-4 has a variable I.F. bandwidth of from 1 kc to 80 kc for analyzing wide or narrow pulsed r-f signals.

A front panel control selects one of three precision calibrated amplitude scales — 40 db log., linear and power. This versatile control allows the user to make simultaneous measurements of signals with large or small amplitude differences.

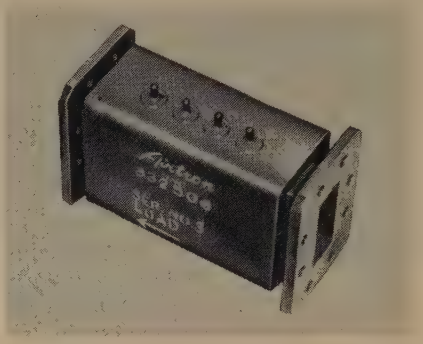
A self-contained marker oscillator, modulated by a calibrated external generator, provides accurate differential marker pips as close as 10 kc for more accurate measurements of small frequency differences. For observing pulse trains and other modulation envelopes, the SPA-4 has a synchroscope output with a 40 db gain.

CIRCLE READER SERVICE CARD 116

REGGIA-SPENCER X-BAND PHASE SHIFTER

Compact and versatile phase shifters capable of high orders of phase shift with low insertion loss are announced by Airtron, Inc., a Division of Litton Industries, Morris Plains, New Jersey.

The X-Band unit, with appropriate shunt susceptance can provide an electronically variable mismatch for frequency control of low-power magnetrons and Klystrons. It can be designed to fit a number of frequency control and antenna phasing systems applications, including magnetron frequency controllers, Klystron frequency modulators, serrodyne phasers, and antenna phase shift elements. Although the frequency range of this unit is narrow, the phase shifter may be modified to suit a number of system applications.



The unit uses a longitudinal magnetic field with a ferrite rod supported in a foam dielectric similar to the technique as worked out by Reggia-Spencer. Phase variation is $\pm 45°$ minimum phase shift; driving power requirements are 0.6 watts maximum; typical DC coil characteristics are 200 ohms max. —100 milliamps max., and power handling capacity of this design is 2 Kw peak power, 2 watts average.

Initial designs are for X-Band; however, other units in the frequency range of 3,000 to 36,000 mc can be developed in either brass or aluminum waveguide upon request.

CIRCLE READER SERVICE CARD 117

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UHF SIGNAL GENERATOR

The Model 201B UHF FM Signal Generator, a product of the Sierra Electronic Corp., Menlo Park, California, covers the frequency range 1300 to 2500 mc.

Featuring extremely linear deviation characteristics, the Model 201B can be frequency modulated by external signals having modulation bandwidths up to 500 kc. A nominal deviation of 2 mc peak-to-peak is produced by external modulation signals having an amplitude of 0.5 volts peak-to-peak. The instruments' low value of residual FM results in excellent CW characteristics.

The RF output of the highly stable generator is variable from 0 dbm to —110 dbm by means of a precision calibrated piston attenuator. An auxiliary output having a fixed level of 0 to —5

VERY

SCALE

412 L EXPEDITE

OPENINGS NOW

ON PROGRAM 412L

(Air Weapons Control Syste

The Heavy Military Electronics Department of G.E. has been awarded responsibilities for Systems Management, Systems Integration and Systems Engineering of AWCS 412L — a Universal Electronic Control System to meet the vast problem of Air Defense outside the continental United States.

Designed for both fixed and mobile applications, 412L will be an ultra flexible system. It can be used to defend a single airfield or — by linking control sites together — provide air control for an area the size of Alaska. By integrating capabilities of several countries, it can operate as the air defense system for an entire continent.

In addition to its prime function of Systems Management, HMED will design, develop and produce the Data Processing and Display Subsystem, which is the heart of 412L.

Also Openings on Diversity of Other Far-ranging Programs in:

Fixed & Mobile Radar; Shipborne Radar; Shipborne Search Sonar, AN/SQS-26 (a new responsibility), Underwater Detection Systems; Missile Guidance; Far Flung Communications.

ENGINEERS • SCIENTISTS

An Unprecedented Opportunity
Enter the Field of

LARGE SYSTEMS

with GENERAL ELECTRIC

Yesterday's systems must today be considered only "subsystems" to be integrated into a larger entity. The growing demand of the defense establishment for super-systems offers challenges of unprecedented scope to the engineering profession.

Now HMED offers able engineers an opportunity to get full exposure to this field of the future—to learn, grow and develop their capacities for systems thinking, by working with men who have been in-at-the-beginning of major systems design and integration programs.

Facts and Figures Behind Growth Opportunities Here:

At HMED you are joining an organization providing professional people with an outstanding combination of CAREER STABILITY plus INDIVIDUAL PROGRESS. In the last few years this G. E. department has *doubled* its dollar business volume; *tripled* its engineering laboratory and office space; *quadrupled* the number of its supervisors and managers, from 26 to 101, with 90% promoted from within; *quintupled* its professional engineering staff.

CUT COUPON ON DOTTED LINE

☐ **COMMUNICATIONS ENGINEERS**—To work with Propagation consultant in frequency choice versus sight configuration, and design of optimum communication and sight configuration. (BS in EE and 3 years' experience necessary)

☐ **RADAR SYSTEMS ENGINEERS**—To integrate varied data acquisition equipment into complex electronic control systems. (Advanced EE degree preferred with minimum 3 years' experience)

☐ **TELECOMMUNICATIONS ENGINEERS**—To design and develop advanced communications subsystems of ground electronic control system complex. (EE degree and 5 years' experience)

☐ **PROPAGATION CONSULTANTS**—To assist in the design, development and management of radar and communications subsystems as applicable to an air defense system. (Advanced degree in EE or Physics with 5 years' experience)

☐ **RADAR RECEIVER & VIDEO PROCESSING ENGINEERS**—To establish receiver design criteria for optimum system performance in varied environments, particularly ECM. (Advanced EE degree or equivalent and minimum 5 years' experience)

☐ **ECM SPECIALISTS**—To provide threat models and consultation to design and management engineers. (Advanced degree in EE and 3-5 years' experience)

☐ **ANTENNA AND MICROWAVE ENGINEERS**—To establish antenna design and sighting philosophies for optimised detection system performance. (Advanced EE degree and 5 years' experience)

☐ **RADAR DESIGN ENGINEERS**—To work on advanced designs and development of receivers utilizing parametric amplifiers. (BSEE and 2-4 years' experience)

☐ **PERSONNEL SELECTION AND TRAINING SPECIALISTS**—To prepare job evaluations, manning structures for complex military systems, and forecast training aid needs. (PhD or EdD required)

☐ **EQUIPMENT EVALUATION SPECIALISTS**—To solve man-machine problems, evaluate alternative components, displays, or techniques and devise simulators. (PhD in Experimental Psychology)

☐ **CABLING ENGINEERS**—To resolve varied problems in grounding and associated shielding problems of complex electronics equipments. (EE degree with minimum 2 years' experience)

☐ **LOGIC DESIGNERS**—To organize and perform logic designs of a high speed digital computer. (Degree in EE, Math or Physics with minimum 4 years' experience)

☐ **CIRCUIT DESIGN ENGINEERS (DISPLAY)**—To analyze equipment and circuit design requirements in data utilization and display subsystems. (Electrical Engineering degree with minimum 5 years' experience required)

☐ **SYSTEMS ANALYSTS**—To conduct system analysis programs and feasibility studies which lead to the conception and development of new systems, subsystems, and equipments of advanced design and function. (Advanced degree in EE, Math or Physics preferred with 3 years' previous experience)

☐ **TECHNICAL WRITERS**—To organize, write and publish progress and planning reports. (Engineering degree preferred with previous technical writing and editing experience in advanced electronics)

Dear Mr. Callender: Please send me an application form and additional information on the positions I have checked off above.

I am a graduate engineer with _____ degree (s) and _____ years experience.

NAME_____

ADDRESS_____

CITY_____ ZONE_____

STATE_____

Mr. George B. Callender, Div. 127-ML
HEAVY MILITARY ELECTRONICS DEPT.

GENERAL ELECTRIC

Court Street, Syracuse, New York

Advanced System Engineers

Programs to Extend Detection and Direction-Finding Systems Capabilities by Several Orders of Magnitude

Sylvania's Waltham Laboratories is accelerating its systems engineering efforts on a widening technological front. The scope of these programs afford advanced system engineers opportunity to direct their individual efforts toward major state-of-the-art advances in synthesis, design and analysis of sophisticated detection and direction finding systems:

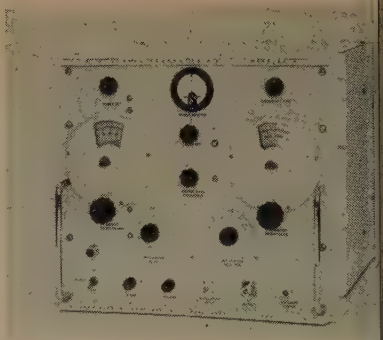
Typical problems toward whose solution you can focus your skills are:

- *Determine the optimum illumination functions for phase quantized antenna arrays.*
- *Calculate the allowable tolerances in a signal processing channel to achieve desired MTI cancellation ratios.*
- *Analyze the performance of matched filter radars in the presence of a dispersive medium such as the ionosphere.*
- *Determine optimum system configurations from a cost-effectiveness and reliability viewpoint.*

If you are systems-oriented and possess a degree in engineering, physics, or mathematics plus previous experience in antenna analysis, statistical communication theory, electromagnetic propagation and operations analysis, you are invited to inquire about a position at Sylvania.

Please write to J. B. Fenno, Dept. 18-J

Waltham Laboratories
SYLVANIA ELECTRONIC SYSTEMS
a division of
SYLVANIA
Subsidiary of
GENERAL TELEPHONE & ELECTRONICS
100 First Avenue
Waltham 54, Massachusetts



dbm is provided for use with an ternal frequency meter.

The Model 201B is fully describe Bulletin No. 127 which is availabl request.

CIRCLE READER SERVICE CARD

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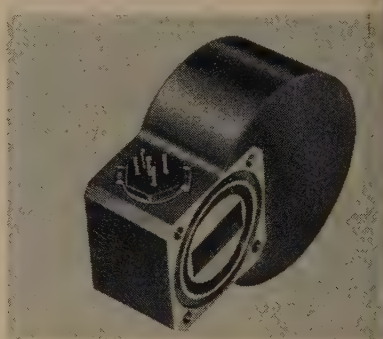
NEW FERRITE SHUTTER SWIT BY KEARFOTT

A new ferrite shutter switch of s size and weight is being marketed Kearfott Company Inc., Microwave D sion, Van Nuys, California.

The Model W574-1A-1 Bilateral Plane Ferrite Switch is readily adap for use in monopulse and doppler r systems and in surveillance and fire trol systems. Having no moving



the device may be used as a shutte switch element, depending upon the cific application.

The Model W574-1A-1 specificat are as follows:

Frequency Range — 13.5 KMC MC; Isolation — 25 db Minimum; I tion Loss — 0.3 db Maximum; I VSWR Transmit — 1.10 Maximum center frequency; Input VSWR Reje 30: 1; Rise Time — 100 μsec maxim Control coil power — 2 watts maxim Ambient temp. — —85°C to 10 Weight — 5 oz.; Size — 2 3/8" hig 1 5/16" wide x 1" deep.

CIRCLE READER SERVICE CARD

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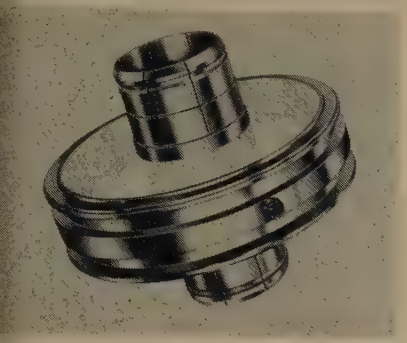
REXOLITE USED AT BMEWS FOR GAS BARRIERS

Rex Corporation, West Acton, M now is supplying Rexolite, a high-di tric constant styrene co-polymer w may be machined to close tolera (0.005 or less) for use in the enginee of coaxial transmission lines in the tion's furthermost polar defense

MEWS. After extensive testing at the tes, Rexolite has shown conclusively s ability to serve effectively as a gas arrier. It is almost totally impermeable moisture, resists crazing at tempera- ires lower than —50°F and, besides its ise of machining, can be cemented adily.

The close-tolerance machinability of exolite is particularly important for the



ose-fitting of barrier material at null oints to prevent moisture contamination the air surrounding the central duct. ir is the principal insulation for coaxial nes.

IRCLE READER SERVICE CARD 120

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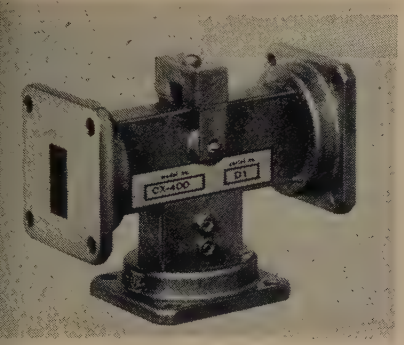
TEE CIRCULATOR

Rantec Model CX400 Tee Circulator a compact, broad band, 3 port device, aving 15 db isolation and 0.4 db inser- on loss over the frequency range 9.1



9.9 kmc. In the band center the inser- on loss is approximately 0.1 db making e unit extremely useful for maser and rametric amplifier applications.

The unit is rated at 1 kw peak, 100 atts average power. The specifications e applicable over the temperature range 55°C to +71°C. The circulator is 1 inches long, and weighs 3/4 pounds.

IRCLE READER SERVICE CARD 121

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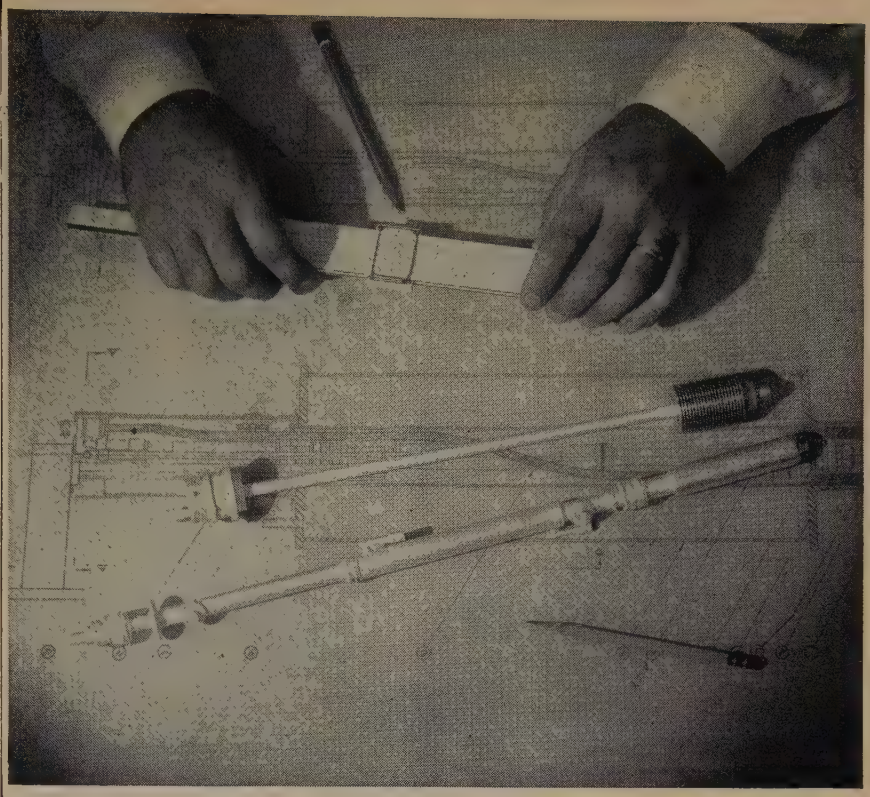
NEW I.F. AMPLIFIER

LEL, Inc., Copiague, N.Y. has intro- ced a new addition to its I.F. ampli- r line. The new amplifier extends the nge of the standard catalogued units 200 mc. The I.F. 39 has a gain of 120 , 3 mc bandwidth, 200 mc center fre- ency, detector output, and provision gain control. A matched input noise ure of 6.5 db is standard, and lower ise figure input circuitry can be sup- ed if required.

RCLE READER SERVICE CARD 122



Senior Level Positions in Fast Growing Microwave Research and Engineering Programs

Project Level Responsibility

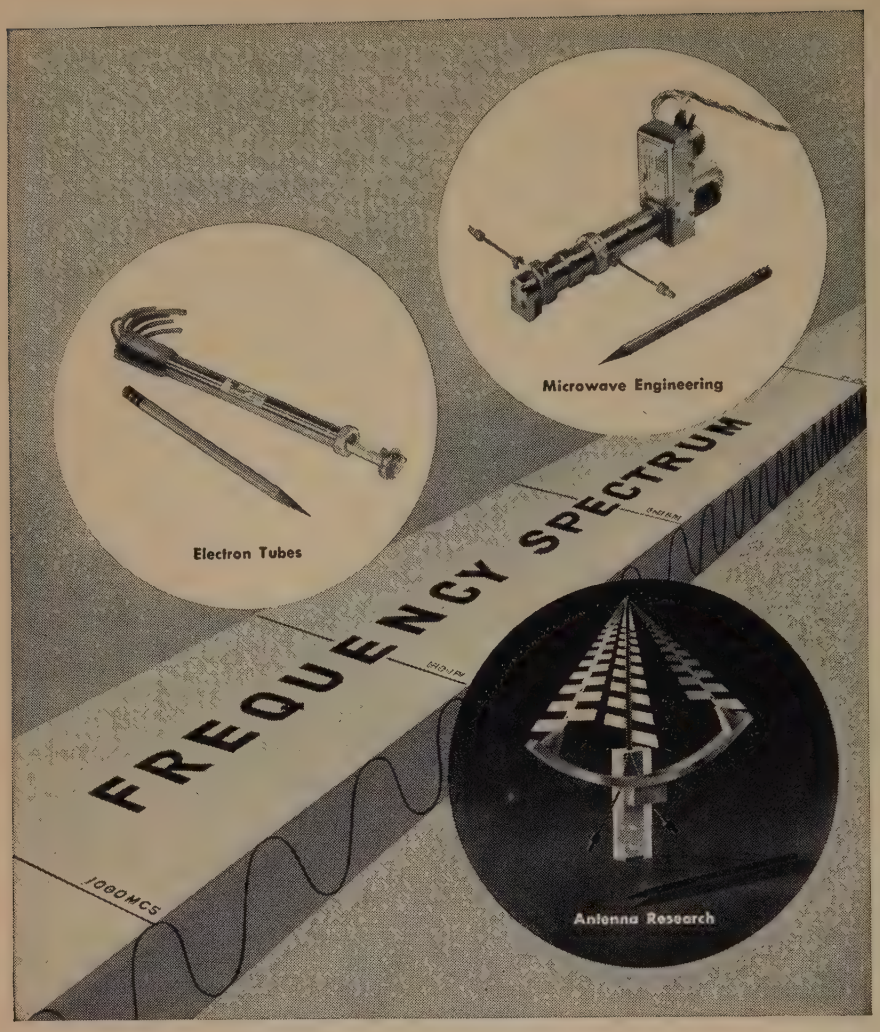
A 100 watt CW, C-Band ceramic traveling wave tube has recently been developed by Eimac. It is just one of the steps Eimac is taking in the field of electron devices to take advantage of microwave frequencies. In TWT's, reflex and amplifier klystrons, Eimac is, and will continue to be, the leader in advancing the state of the art. Career opportunities are now available for outstanding engineers with BS, MS, and PhD degrees with a company specializing in electron tubes.

1. Research Engineers and Scientists to conduct theoretical and experimental research in microwave measurements, microwave tube problems, plasma physics and circuit design.
2. Microwave Engineers to test and evaluate tube performance and design of VHF and UHF circuits with respect to klystrons, negative grid tubes and traveling wave tubes.
3. Project Engineers to assume responsibility for existing and newly-approved projects in high power klystrons... including design and testing of electronic guns, cavities and related tube components.

Salaries offered are excellent and, naturally, Eitel-McCullough will pay relocation expenses to the company's facilities in Salt Lake City, Utah and San Carlos, California. All replies will be honored with the strictest confidence. Please write: C. F. Giesler, Dept. M, Eitel-McCullough, Inc., San Carlos, California.

Eimac

EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA



OPPORTUNITIES IN UHF AND MICROWAVE RESEARCH AND DEVELOPMENT

Never before has such high priority been given to microwave research and development . . . never before have the opportunities been so great in this field for the qualified engineer and scientist.

The Research Center of the Bendix Aviation Corporation—The RESEARCH LABORATORIES DIVISION—is expanding its programs in the UHF and microwave field to create interesting and challenging positions for qualified personnel.

Technical openings are now available in the following fields:

ANTENNA RESEARCH in electronic scanning, log periodic antennas, microwave optics.

MICROWAVE ENGINEERING—in ferrite devices, electronically controlled phase shifters, parametric amplifiers.

ELECTRON TUBE research in BWO and TWT from 1,000 to 150,000 mcs.

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FABULOUS SIXTIES! OR DECADE OF PROBLEMS?

By
WILLIAM BAZZY
Publisher, the microwave journal

Volume II of "the microwave journal" is now history. The road we have traveled between the first and welfth issues has been most interesting. Our experiences have been varied and exciting. We have been elcomed by many, and snarled at by a few. However, e have borne all such trials gladly and have rationalzed the rejection of the few by the healing balm of a rowing publication.

It would be of interest to the industry to review 1959 s far as the microwave field is concerned, and to try o see what lies ahead in 1960.

irculation Figures Reflect Industry Trends

When "the microwave journal" was first started, a ailing list of 12,000 engineers and management people as compiled. This December issue is being mailed to ore than 23,000 readers of this same quality in all rners of the globe.

The circulation increase is on the upsweep. The onthly increase averaged 600 to 700 in the first half f 1959. The latter half of the year has seen the circulaon increase rate move up steadily to over 1000 a month present writing. We are now estimating that requests r "the microwave journal" will run to 30,000-35,000 gineers and management persons. Originally 300 mpanies were on our list. To date over 800 comanies (not including military or government installaons) are indicating activities in the field of microaves. Also of interest is the surge of activities noted the mid-west, which has traditionally been a major ass production area. The major concentrations of miowave activities are in the mid-Atlantic area, with both e northeast and west coast areas about evenly divided concentration of talents and companies.

ilitary Electronic Equipment*

The greatest upsurge in volume of electronics output ring 1959 has been in military electronics production which comprises over half of total electronics activity research and development expenditures are included. his expansion in military electronics activity, which be- n in mid-1958, is due to a combination of accelerated issile and space programs, previously deferred mili- ry procurement, and the increasing electronic content military hard goods. Unless the international situan changes, military electronics activity should conue to increase.

Commercial and Industrial Electronic Equipment*

After leveling off late in 1957 and early in 1958, commercial and industrial equipment output continued the late 1958 upward trend throughout the first six months of 1959. Major contributing causes were: rising military electronics output, increased capital investment throughout the economy, the trend towards automation, the civilian space programs, and the increasing, electronics content of capital goods and other products required by the business community. In another decade, the commercial and industrial electronic industry may be the largest sector of all the electronic industries.

Microwave Industry Dollar Volume

The size of this microwave industry is quite impressive. The dollar volume associated with the varied phases in this field is growing steadily. Marketing figures have been scarce, but during 1959, we have asked various industry representatives to project their analyses of the market. In January, Dick Barlow of Hughes Aircraft noted the rapidly moving Ferrite market. His projection for the next few years indicated a possible growth to $75,000,000. Most industry sources indicate 1959 sales will run approximately $15 million.

In February Charles Creaser of D. S. Kennedy noted the "Large Antenna" market at approximately $25 million. In May, Paul Garrison of ITE estimated the "Small Antenna" market at about $250 million. Dave people, in their profile of November, 1958 felt that the sub-systems would run close to $200 million. The Bomac people, in their profile of November, 1959 felt that the microwave tube market should total $250 million for 1959. Information gleaned from other industry sources corroborate these amounts. A release from the Business and Defense Services Administration (noted on page 52) gives the latest analysis of the tube market.

It is felt that total component sales (including subsystems and antennas) in the microwave field will total approximately $1 billion. Antennas are included as a component and not as a complete system. Bill Bourke, President of Narda, estimated that the catalog item sales for the test instrument industry would amount to about $40 million annually. Approximately $10 to $15 million worth is in waveguides and coaxial products with the remaining $20 to $25 million in the complex

*BSDA Report, U.S. Dept. of Commerce, August, 1959.

microwave electronic instruments. Microwave instrument sales are expected to expand at the rate of 20% each year for the next five years.

Going a step further, we would hazard the guess that, including the systems associated with frequencies 100 mc/s and above, the dollar volume in this field would be well over $3.5 billion. A rough calculation used to give "ball-park" values for total figures is as follows:

"the microwave journal" circulation is now at 23,000. The rate is increasing rather than slowing down. Therefore, indications of leveling off are not in sight.

Assume 25,000 as a conservative number of engineers occupied fully or in part with activities associated with the microwave field. As an average, the engineering force of a typical company is about 10% of the total number of people employed. Thus we arrive at about 250,000 people in this microwave industry. The figure given by the Military for the gross sales dollar cost per employee is $16,000. Multiplying these two items, we arrive at $4 billion. One can interpolate for his own needs the correction figure to be used in this case. It would appear that the microwave industry is much larger than many have ever realized.

It is readily admitted that the conclusions are not based on a sophisticated market analysis. However, we have been privileged to sit in with many marketing and management groups discussing this survey. In most cases, there was general agreement, and in some cases our conclusions were considered conservative.

Total electronics manufacturing output in 1958 was over 2 percent of total manufacturing sales and almost 5 percent of durable goods sales. The 1958 estimated value of manufacturing output of electronic products was almost $7 billion, and 1959 output should reach $8.5 billion, a 20 percent gain over 1958. This estimate does not include extensive electronic research and development expenditures throughout the economy — which totaled between $1.5 and $2.0 billion in 1958.*

The projections of the dollar volume to be expected over the next five years in most cases have been exciting. Studies have been seen that indicate a 25 to 50% annual growth in some areas. Most surveys agree that the industry total should double in the next decade. It is possible that this growth factor may materialize in the next five years.

The increasing role of microwaves in space communications, the possibilities of generating super power at these frequencies, and the transfer of this energy by electro-magnetic radiation show great promise for the future. The exploration of the millimeter wave bands, opening new and almost unlimited uses of the spectrum, is being realistically appraised. An interesting paper discussing this subject is scheduled to appear in the January issue when A. W. Straiton of the University Texas will present a fine article on millimeter waves

Global Interest in Microwaves

We have noted an increasing interest in microw activities from every spot on the globe, with the exc tion of Red China. The great migration of Ameri businessmen across both oceans has pointed up in the creasing interest in the foreign markets. We also n that the oceans allow travel both ways. The effect increasing imports on our electronic economy is n beginning to show. The effort to sweep this probl under the rug is puzzling. Efforts to gather opini about this matter meet with shrugs — or indicati are given of a large problem yet — ! We know it a shrinking world and marketing concepts are n on a global basis, but have we geared our thinking a our marketing to this concept? In the year to cor "the microwave journal" will make every effort to industry expressions on this matter.

All these points imply a positive picture of expansi in the years ahead. However, it is not in the nature being that clouds do not darken the horizon. It is t that the European Common Market is showing gr promise — a promise also of strong competitive pr sures. Our political philosophy currently appears point to a world-wide market. Efforts to sweep t problems under the rug CANNOT continue. The r ing volume of imports must be faced. Frankly, t office has been impressed with the scope of activit from these areas. The competitive spirit of these peop plus the technical proficiency of their scientific grou cannot be under-estimated. A well-placed official in o of our largest corporations claims that the strug ahead will be intense.

It is not our intent to delve into these matters deep in this article. During 1960 we hope to bring the vie of industry sources to detail their outlook about the matters.

Fabulous 60's may be just ahead. Perhaps the "pitc men" have hit the right theme. Microwave peop appear to have a big year ahead. We just hope no o stumbles over that mound building up under the ru

It is that time of the year when men of good w wish each other the best of the season. I wish acknowledge the fine efforts of our board of associat Ted Saad, Seymour Cohn, Henry Jasik, Ben La Marshall Pease, Tore Anderson and Gersh Wheel have established "the microwave journal" well in t industry. To "Fearless Ted Saad" a special word thanks and reassurance. Even though "the journal" a tivities may, at times, take us "out of this world," w shall effect the re-entry when the situation requires to "sign the checks."

George at the Forge

The day the mobile radar was delivered to Washington at Valley Forge, it was so cold a man's shadow froze to the ground. Nevertheless, the Father of his Country managed to work up a good head of steam when he saw the unit.

*"Idiots!" he stormed. "Why do they send me radar when we need food and shelter and clothing? What good is it? Does it have Bomac tubes?"**

"No sir," his orderly shivered. "It doesn't seem to have any tubes at all. But it might make a nice warm fire."

"I was thinking the same," Washington said. And, without another word, he went and got a little hatchet and chopped and chopped. The wind blew and the chips flew. Soon, the installation was reduced to kindling.

"That's more like it," the General said when he was done. "Now, if someone will hand me a match . . ."

But he never finished the sentence. The ice on which he was standing suddenly gave way, and he disappeared into the frigid water.

"General, general are you all right?" the orderly asked as he fished him out.

"I'm afraid so," Washington said. "But you'd better put a sign here to warn the others."

So, that was why the famous sign was put up — the sign you can see today when you visit Valley Forge. You know the one.

It reads "George Washington slipped here."

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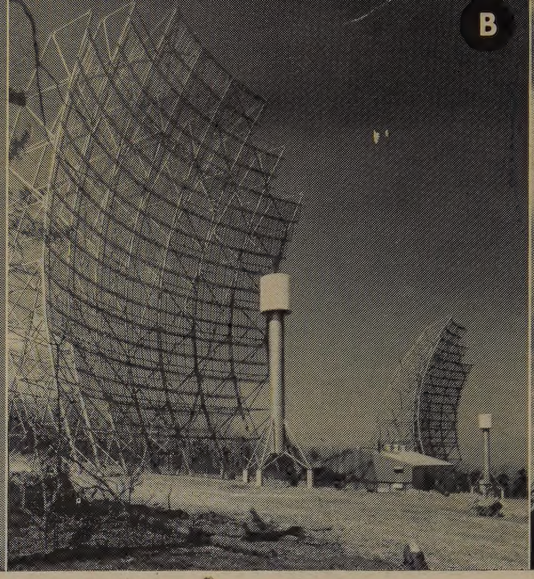

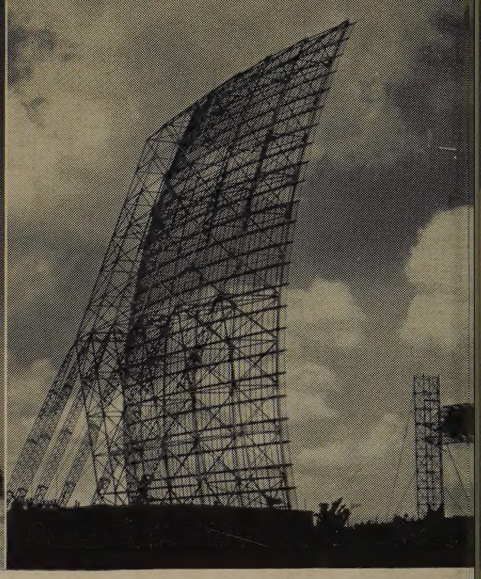

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B **SCATTER ANTENNAS** — *One end of a scatter link showing two 120-foot antennas. 28- and 60-foot models are also available.*

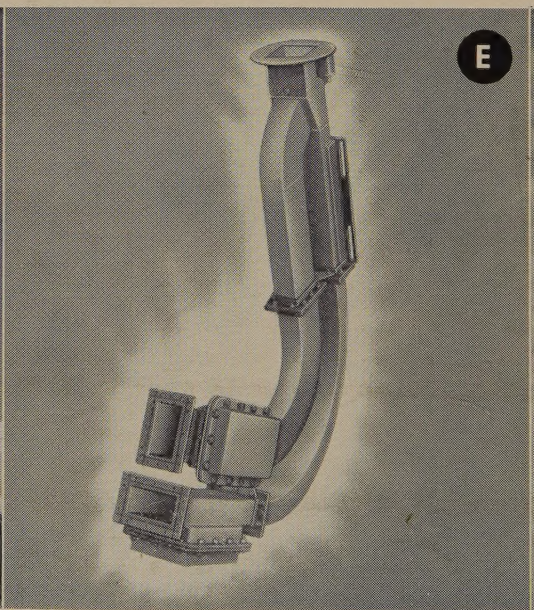
C **RADAR ANTENNAS** — *A giant radar antenna forerunner to the BMEWS Program. Dozens of conventional types are also available.*

D **RADIO TELESCOPES** — *An 84-foot radio telescope listens to the heavens whisper. 28- and 60-foot models are also available.*

E **WAVEGUIDE COMPONENTS** — *A dual polarized feed with two waveguide inputs. Other large size components include many types of horns, duplexers, transitions, straight sections and bends.*

F **FIELD SERVICE** — *Kennedy Field Service engineers erect an 84-foot radio telescope. Other services include site selection, constructon, personnel training and servicing.*

G **RESEARCH AND DEVELOPMENT** — *Kennedy's antenna service includes basic R & D in microwave propagation.*



THE solution to antenna problems begins when someone says: "Let's ask Kennedy!"

A few of the many reasons why are shown on this page. These Kennedy antennas are setting new standards for all-weather reliability and versatility wherever they serve throughout the free world.

Kennedy antennas come in many shapes and many sizes. But whatever the type, and whatever the conditions under which it must serve, Kennedy can offer a design that fully measures up to specifications.

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